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Practical Wound Management for Nurses Mini Series

Session 2: Debridement and Open Wound Management

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WOUND DEBRIDEMENT

Aims of Debridement

Debridement is defined as the removal of damaged tissue or foreign material from a wound. Necrotic tissue will delay wound healing and increase the risk of wound breakdown by acting as a nidus for infection. Necrotic tissue also slows wound healing by obstructing re-epithelialisation and wound contraction.

Traumatic wounds can be managed by primary closure, delayed primary closure or secondary closure; or they can be left to heal on their own by secondary intention. The most important consideration in deciding whether, and when to close a wound are the degree of contamination (bacterial and foreign material) and necrotic tissue present. A combination of lavage with debridement techniques enables the reduction of the level of contamination and the presence of necrotic tissue to a point where the closure technique chosen can be safely carried out. This may not be possible in a single procedure; wounds that have extensive contamination and ischaemia may require repeated debridement, and the use of more than one debridement technique, before closure can be considered. The mainstays of debridement in acute wounds are surgical and mechanical debridement.

Surgical (or 'sharp') debridement

In surgical debridement, devitalised tissue is cut from the wound, allowing rapid and effective tissue removal of tissue as well as thorough wound exploration and assessment of underlying structures. Debridement should be treated as any other surgical procedure; strict aseptic technique should be used to prevent introducing further bacterial contamination into the wound, therefore the area is draped, and the clinician gowned and gloved.

The aim is to remove devitalised tissue, whilst preserving the blood supply to healthy tissue; to achieve this the following points should be adhered to:

- Use a sharp scalpel, and change the blade frequently;
- Do not use scissors, they tend to crush as they cut;
- Handle viable tissue gently, do not use self-retraining retractors;
- Handle skin edges with skin hooks, avoid rat-toothed forceps etc.

Generally two approaches to surgical debridement can be used; 'en bloc' or layered debridement. The choice depends on the availability of surrounding tissue for closure, and therefore the need to preserve as much skin as possible.

En bloc debridement

In areas where there is adequate normal tissue to allow closure afterwards, the whole affected tissue can be excised wit h a border of healthy tissue – in a similar fashion to removing a tumour with healthy margins in all planes. This is termed en-bloc debridement, ideal areas for this technique include the trunk or proximal limbs where there is plenty of available skin to close the deficit. The wound is usually packed with surgical swabs and sutured closed prior to excision of the entire wound.

Layered debridement

More commonly when debriding a wound, devitalised tissue is removed gradually in layers, allowing conservation of tissue where possible, this may be important in areas such as the lower limbs and feet where there is inadequate skin to allow en-bloc debridement.

Superficial tissue is removed first. Followed by debridement of deeper tissues. As debridement progresses, instruments can be changed or disinfected and rinsed to prevent contaminating areas that have already been debrided.

Assessing which tissue is non viable and should be removed is not as straightforward as it sounds. In areas of non-vital tissue (i.e. skin, muscle, fat) one option is to cut tissue back until it bleeds, on the understanding that haemorrhaging tissue is healthy tissue. Certain factors can affect the degree of bleeding from cut tissues including systemic or local vasoconstriction, tissue temperature and coagulation defects, therefore this more aggressive approach could result in removing viable tissue. When removing viable tissue is an issue, due to the requirement to preserve as much tissue as possible, a more conservative approach is taken. A line of demarcation between dark (or very light) tissue and normal coloured tissue is a good indicator or non-viable tissue. Where there is any doubt over an area it can be left and re-evaluated at the next assessment, when a line of demarcation may have developed, this is sometimes termed ‘staged’ debridement.

Copious lavage should be performed during surgical debridement, to flush debris and contaminants and also to re-hydrate tissues, which assists in the assessment of tissue viability.

Surgical debridement is often followed by the use of dressings to achieve mechanical debridement. This is especially the case where a single surgical debridement is not sufficient to produce a wound bed suitable for closure. A common technique is to assess and surgically debride the wound daily, whilst using dressings inbetween procedures to mechanically debride the wound.

Mechanical Debridement

Mechanical debridement utilises adherent dressings to remove non-viable tissue and foreign material from a wound bed.

Wet-to-dry dressings

Wet-to-dry dressings have been used for decades in humans and they are a very useful tool in wound management in veterinary practice. Their effectiveness relies on the adherence of the dressing to the wound bed, which on removal lifts the debris and necrotic tissue that becomes trapped in the mesh of the dressing.

The application of wet-to-dry dressings is straightforward, and involves readily available materials. A sterile gauze swab is moistened with sterile saline and placed in contact with the wound bed; this is then protected by standard secondary and tertiary bandage layers. The moisture from the swab dilutes the exudates in the wound, which is absorbed into the secondary layer and the swab dries and adheres to the wound surface. The dressing needs to be changed at least daily before any strike through is noted; any delay leads to a delay in healing and increased risk of infection. Removal is often painful and sedation or anaesthesia is usually required.

Wet-to-dry dressings are very useful, cost effective, and easy to apply; but if applied incorrectly can delay healing, common mistakes in technique that must be avoided are:

- Don’t over wet the swabs. Wring them out well; otherwise they will not dry out and will not adhere to the wound;

- Do make sure the wet swabs are in direct contact with a highly absorbent secondary layer’

- Do place several layers of absorbent padding, sufficient is needed to absorb exudates before strike through;

- Do make sure the wet swabs are in direct contact with the secondary layer.

Debriding dressings can be used anywhere on the body; if they are used in areas that are difficult to bandage, such as the greater trochanter, or on the trunk, a ‘tie over’ technique can be used. In a tie over dressing, loops of monofilament suture material are tied at intervals around the wound bed. The wet-to-dry dressing can then be placed over the wound bed, followed by cotton wool or a laparotomy pad followed by a tertiary layer. The dressing is then held in place by nylon tape threaded through the suture loops. During redresses the suture loops are left in place and utilised for the next dressing.

In wounds that are producing large amounts of low-viscosity exudates, a dry-to-dry dressing may be preferable. The dressing is identical, other than the swabs are not wetted, and are placed onto the wound dry. This ensures that even though there is a large amount of exudate, the swab becomes wet, the fluid is absorbed into the secondary layer, and the swab becomes dry again.

Other debridement methods

Autolytic

Autolytic debridement is a selective debridement brought about by the release of the patient's own proteolytic enzymes (e.g. collagenase, elastase) and the activation of phagocytes. These enzymes soften and breakdown necrotic tissue, and are mostly produced by leucocytes. This is a natural process that occurs in all wounds, but its action can be enhanced by using products that promote and maintain an ideal moist wound environment that promotes the activity of leucocytes and macrophages. The moist environment also promotes the swelling of necrotic tissue, which loosens it from the wound bed.

Hydrogels are polymers that are saturated with water, different gel forming agents such as carboxymethylcellulose are incorporated into most hydrogels. Hydrogels 'donate' water into the wound to promote a moist environment; they should only be used in wounds with moderate or no exudates. Hydrocolloids are composed of carboxymethylcellulose, gelatin, pectin, elastomers and adhesives that turn into a gel when exudate is absorbed, these absorptive dressings can be used in exudative wounds. Autolytic products do not damage healthy tissue, and are said to promote the formation of granulation tissue and epithelialisation.

Honey

Records of the use of honey extend back more than 4000 years. Honey is a supersaturated sugar solution containing 30% glucose, 40% fructose, 5% sucrose and 20% water as well as other substances such as amino acids, vitamins, minerals and enzymes. For wound management honey is available in tubes, or impregnated into dressings.

Honey promotes autolytic debridement, while having antimicrobial effectiveness. Honey osmotically draws fluid from the surrounding tissues, this reduces wound oedema and increases exudates which both promote autolytic debridement. Antimicrobial activity is likely to be due to a number of factors; osmotic dehydration of bacteria, low pH (3-4.5), release of small amounts of hydrogen peroxide or methyglyoxal .

Honey should not be used in dry wounds where its osmotic effects wound further dry out the wound.

Enzymatic

Enzymatic agents are relatively selective in loosening and removing necrotic tissue. No veterinary product exists in the UK, but in the USA an ointment derived from bacteria (*Bacillus subtillus*), which contains the enzyme sutilain, is available and can be used in wounds with minimal necrotic tissue. A much wider range of proteolytic enzyme preparations are available for wound management in humans, including enzymes derived from plants (e.g. pineapple), bacteria and animals (e.g. Antarctic krill).

Larval

The use of maggots in wounds is an idea that has been around for hundreds of years. In human medicine the most commonly used maggot is that of the greenbottle fly (*Lucillia sericata*). The advantage of maggots is that they selectively debride necrotic tissue while sparing healthy structures; this may be advantageous in areas where vital structures exist and aggressive surgical debridement is therefore contraindicated. In human use the maggots are restrained with a net incorporated into the dressing and are removed after 3 days.

Advances in Debridement

Hydrosurgery

Hydrosurgical units emit a very high-pressure stream of saline that cuts tissues. The Versajet (Smith and Nephew) is the most commonly used unit in human hospitals where they are used for debridement of wounds, chronic ulcers, and burns. These units should not be confused with 'water piks' that deliver a stream perpendicular to the wound, and are used for pulsatile lavage. In a Versajet the stream crosses a window in the hand piece, and is orientated parallel to the wound bed, allowing tissue to be 'shaved' off; the saline passes into an evacuation collector.

The Versajet not only cuts with the saline stream, but the stream also creates a vacuum ('Venturi' effect) that evacuates the ablated tissue and debris along with the saline, leaving a clean wound bed. The speed of the stream is controlled on the console.

Human reports suggest that Versajet is equally, if not more effective than conventional surgical debridement, by causing less damage to viable tissue. Other perceived advantages include shorter surgical time, shorter hospital stays, and less risk of injury or aerosol contamination compared with surgical debridement with lavage.

Conclusion

In some traumatic wounds it may be possible to debride the wound surgically in one procedure, e.g. fresh laceration with minimal tissue damage, or by en-bloc debridement on the trunk. However, in more contaminated wounds or in areas where the preservation of vital structures is imperative, or where maintaining as much viable skin as possible is important, often more than one procedure is required (a technique known as staged debridement). In staged debridement, surgical debridement can be repeated at intervals, with the use of additional debridement in between: mechanical, autolytic, or enzymatic. In the human field, hydrosurgery is gaining popularity due to its benefits in speed and establishing a clean wound bed.

During the process of debridement, it is important to keep inspecting and re-evaluating the wound. As soon as the clinician is confident that contamination and necrotic tissue has been reduced to a level where phagocytosis can deal with the remaining impediments to healing, wound closure can be considered. It is often more cost effective to reconstruct a wound at this point rather than a

prolonged period of second intention healing which can rapidly become expensive due to repeated dressings and sedation.

WOUND DRESSINGS

Advanced dressings

Hydrogels

These are used in wounds that are thought to be at risk of drying out. These gels are composed of 70-95% water in combination with variable quantities of hydrophilic polymer base such as carboxymethylcellulose or alginate. The main role of hydrogels is a fluid donator as they are idea for use in dry wounds but they can be used as an aid to debridement in fragile wounds. Hydrogels have the ability to both donate and trap water; this means they have the ability to absorb wound exudate as well as hydrating and debriding necrotic material within the wound.

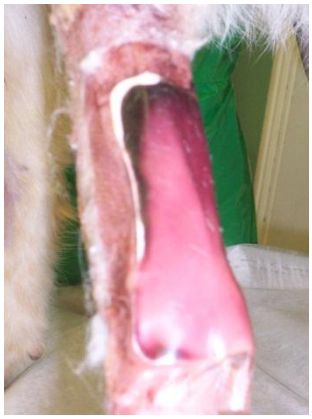
A secondary dressing is required in order for these hydrogels to work efficiently and this should ideally be a foam or dressing with a semi-permeable film backing in order to maintain humidity and a moist wound environment.

Hydrocolloids

These dressings are usually used in wounds that require additional moisture and natural debridement. These dressings actively stimulate wound healing and encourage debridement as they degrade on interaction with wound exudate. These dressings can be difficult to apply in animals. They are best used in dry to semi-dry wounds requiring maintenance of an optimal moist environment. The dressings consist of polymers suspended in an adhesive matrix, the dressings adhere to the normal skin around the wound edges and are left in place for several days where they provide a near ideal wound environment. Users should be warned that on initial removal the wound can look much worse; this is because they dressings swell and liquefy as the exudate is absorbed as well as giving the wound a yellowish appearance – this however is normal and once the wound has been lavaged it should look much improved.

Polyurethane Foam dressings

Foams have a highly absorbent capacity and act by drawing excess exudate away from the wound, maintaining some moisture conservation through humidity to keep the wound moist. These dressings are commonly applied on top of other products, e.g. hydrogels, honey. The ability of the dressing to absorb exudate is dependent upon the viscosity of the exudate and also the dressing's MVTR (moisture vapour transfer rate). This semi-permeable membrane backing allows oxygen exchange and controlled evaporation, resulting in a moist wound environment. Foam dressings are now available with antimicrobial properties. Kendall's AMD Antimicrobial foam dressing is a new PHMB impregnated hydrophilic polurethane foam dressing; PHMB works as an antimicrobial agent exhibiting broad-spectrum activity against bacteria and fungi. This PHMB within the dressing attacks bacteria in wound exudate as it is absorbed. The AMD foam dressing is effective against staphs including MRSA, Pseudomonas, Proteus etc. The dressing itself creates a moist wound environment as well as inhibiting pathogenic organisms from growing in or penetrating the dressing.



Exudate absorption can be seen from the outside of the foam dressing, meaning the dressing can be left in place until its absorption capacity is reached.

Alginates

Alginate dressings are fine fibrous dressings used to absorb moisture. They are presented as either a rope or flat form. These dressings are derived from kelp and consist of varying proportions of guluronic and mannuronuic acids. The wound exudate interacts with the alginate to release cations that actively stimulate wound healing via the inflammatory cascade, allowing the release of endogenous growth factors into the wound. These dressings can be useful in the treatment of wounds that have become stationary – in this case they should be moistened before use

Sodium chloride dressing

This is a relative newcomer to the veterinary dressing market. This is gauze dressing which his saturated in a 20% hypertonic saline solution. This dressing promotes biological cleaning and the autolytic debridement process in non-infected and highly exuding wounds. The dressing stimulates the inflammatory response and granulation tissue formation. The hypertonic saline within the dressing has an osmotic action pulling necrotic tissue and bacteria away from wound. Sodium chloride dressings are indicated for heavily infected and necrotic wounds. This dressing should be replaced every 24 hours and their use stopped once debridement is complete

Super absorbent dressings

Wounds which produce vast quantities of exudate can be very difficult to manage, historically nappies have been used to manage such wounds however, recent dressings have been designed to cope with very high volumes of exudate by incorporating polyacrylate crystals into the dressings in combination with hi-tech silicone adhesives to make them very ‘wearable’. These dressings are very useful when used on patients with Penrose drains in place.

Antimicrobial dressings

Honey

Manuka honey is currently the first choice in wound management due to its excellent anti-microbial effects.

Manuka honey is derived from Manuka plants and requires a UMF (Unique Manuka Factor) of 10 or more in order to be used in wound management to ensure its potency and anti-microbial effects are adequate, and also to ensure it is effective against common wound pathogens including Pseudomonas spp. MRSA and E coli. Honey manufactured for medical use is prepared specifically involving high level filtering to remove debris and beeswax as well as gamma sterilisation.

Silver dressings

Silver and its salts have antiseptic and antibacterial properties. Historically, silver has been used as a paste for the treatment of burns however the introduction of silver dressings has made a huge impact on wound management in recent years.

The silver in the dressings ionizes to release active silver ions into the wound. Nanocrytalline silver has been developed as a product that rapidly releases high concentrations of silver into an infected wound. Dressings are available that can be left in place for up to 7 days. The dressings require activation prior to use by moistening with water for 10 seconds. Silver has a similar anti-microbial effect to Manuka honey and is effective against Pseudomonas spp, MRSA, E. coli and common yeasts and fungi including Candidia.

It should be remembered that holistic assessment and treatment of the patient is essential in order to ensure that the healing potential is optimised.

Bandages and dressings

The on-going management of the wound to allow secondary closure, delayed primary closure or second intention healing involves protection of the wound surface by bandaging.

Bandaging aims to achieve the following:

- Immobilisation of the wound surfaces, ensuring that the capillary buds and migrating epithelial cells are not disrupted and therefore maximising the rate of wound healing;

- Protection of the wound from trauma and contamination (including self-trauma and bacteria migrating through the dressing onto the wound);

- Pain relief for the patient;

- First aid – bandaging of a wound may be a temporary first aid measure to protect the wound from further contamination and aid haemostasis while a trauma patient is stabilised. The wound should be covered with a non-adherent dressing and an absorbent secondary layer. At this stage, ointments, antiseptics or wound powders may only serve to cause chemical damage and complicate debridement later on.

The most important layer of the dressing in terms of wound healing is the primary contact layer which should be chosen according to the condition of the wound. In the early stages, if the wound is still producing exudate and necrotic debris, debriding dressings are indicated. As the wound improves and granulation tissue is evident, a semi-occlusive non-adherent dressing may be used which may be used which will allow exudate to be drawn away from the wound into the secondary layer of the bandage, while keeping the wound surface moist and protected. New tissue is not damaged on removal. Petroleum gauze products allow excess fluid through, but may allow slow epithelialisation. Smooth non-adherent dressings, such as Melolin (Smith & Nephew), may be used as the exudate reduces.

Occlusive dressings are indicated once there is no infection and the wound is healing well. They keep the wound bed moist and warm and protect the new epithelium from abrasion. The hydrocolloids are a suspension of starch polymers in an adhesive matrix. They absorb fluid from the wound and form a moist gel. The edges of the dressing overlap with normal skin and form a seal, so that secondary dressing layers are not needed. This stimulates granulation tissue, allows rapid epithelialisation and also has some analgesic effect. Hydrocolloid dressings may prove expensive if

dressing changes are frequent, but can be left in place for up to five days. These dressings will cause maceration of the tissue if the wound is exudative and they do not allow debridement. Furthermore, the adherence of the dressing at the wound edges may 'splint' the wound and prevent contraction. Intrasite gel (Smith & Nephew) is a hydrocolloid gel that may be used in a concave wound to allow the advantages of the moist environment but without being completely occlusive. The gel should be covered with a non-adherent dressing and a secondary absorbent layer.

Alginate dressings (e.g. Kaltostat; BritCair) also form a gel after absorbing wound exudate, and encourage epithelialisation in the same way. As they are not occlusive, they may be used as an alternative to the hydrocolloids if there is any doubt as to the state of the wound. Kaltostat may be useful for the transition from debriding dressings to hydrocolloids in the management of open wounds. The wound should be irrigated with sterile saline to remove the dressing.

All of these primary layer dressings are only as good as the bandage holding them in place. They must be changed regularly. It is important that the owner appreciates that if the bandage becomes wet it should be changed immediately.

Generally bandages are composed of three basic component layers:

- Primary (contact) layer
- Secondary (intermediate) layer
- Tertiary (outer) layer

<u>Primary layer</u>

This involves the various dressings available for use as the contact later.

<u>Secondary layer</u>

It is essential that all layers of a bandage are correctly and meticulously applied in order to avoid the common complications that can arise from inadequate, unskilled or incorrect application. The role of the secondary layer in wound management, in addition to providing support and comfort, is absorption. It acts as a 'trap' for exudative fluids from the wound; evaporation from this layer helps to prevent bacterial strikethrough. To aid its absorptive role this layer needs to have good capilliarity and should be thick enough (single or preferably multi-layered) to collect the fluid and pad the wound. The intermediate layer must be in close contact with the primary dressing but it should not be applied so tightly as to limit exudate absorption. Suitable materials are hospital quality absorbent cotton wool or synthetic materials.

Tertiary outer layer

The outer layer serves to hold all the other layers of the bandage in place. In a multi-layered bandage (e.g. modified Robert-Jones), intermediate layer of conforming gauze and absorbent material may be used prior to applying an outer covering such as an adhesive wrap or preferably a self-adhering dressing. It is important that the outer layer allows evaporation of fluid but minimises external fluid absorption. Plastic bags which may be placed over the distal dressing should only be left in situ for a minimal period to prevent excessive fluid retention, with the increased risk of bacterial strikethrough and tissue maceration.

Tie-over (bolus) dressing

Tie-over (bolus) dressings are a useful method of securing contact layers to all parts of the body, where conventional bandaging techniques are of limited value, e.g. the greater trochanter. The most common method of securing such a dressing is to use several loops of 3 metric (2/0) monofilament nylon sutures placed approximately 2cm from the wound edge. Umbilical (nylon) tape is passed through these loops to secure the dressing; the tape is laced across the dressing through the skin sutures. Alternatively, long strands of suture material may be stapled 2 to 3 cm from the wound edges all around the wound; these sutures may then be tied over the dressing to hold it in place. The entire area should then be covered with an outer bandage.

Non-adherent dressing is applied to the wound and cotton wool is then placed in the centre of the dressing. The edges of the dressing are then folded over and secured with either sutures or umbilical tape.

Pressure relief bandages.

Pressure relief dressings are indicated for the prevention of decubital ulcer type lesions or treatment of superficial ulceration secondary to bandages or casts. Generally, doughnut-shaped and pipe insulation are employed to protect the area concerned by avoiding pressure over bony prominences. Care should be taken when using doughnut-shaped bandages as they can in some instances be counterproductive as they produce a 'halo' compression of the skin around a bony prominence. This compression can occasionally be severe enough to compromise the circulation and therefore delay wound healing. Soft foam pad (pipe insulation) can be used parallel to the lesion so as to not encircle the wound so that the circulation is not compromised.

Robert Jones bandage

This bandage was named after a famous orthopaedic surgeon, Sir Robert Jones (1858-1933); this type of bandage is used to support fractures of the limbs distal to the elbow or stifle. It is frequently used as a first aid measure or in combination with other methods of fixation. It is also highly useful in the prevention of or reduction of oedema, and in restricting the movement of a limb.

Placement

Any wounds which are present on the limb should be suitably dressed. Two 2.5cm adhesive, non-elastic strips, e.g. zinc oxide, are attached to the limb. These tape strips should be long enough to continue for 10-15cm distal to the limb, these extended strips are later used to create the 'stirrups' which are used in order to prevent the bandage from slipping down the limb. The padding material is then applied evenly over the entire surface of the limb until the limb is approximately three times its original width. This padding layer should extend from the level of the toes and should extend proximally to include the joint proximal to the fracture. The most widely used, and readily available material is cotton wool; this is cheap, easy to compress and will tear into suitable widths to allow for the natural angles and contours on the limb.

When placing such dressings on the hind limbs, the leg should be slightly flexed before the padding layer is applied, so that the limb will not be dragged when the bandage is finished, as it is effectively longer than the opposite limb.

At least two layers of conforming or white open weave bandage should then be firmly applied over the cotton wool layer, working from the toes proximally. Conforming bandage, i.e. bandage which takes the shape of, or conforms well to the shape of the area in which it is being applied. The

bandage should be unrolled in short sections, always keeping the flat surface towards the limb; with each turn the bandage should overlap the previous turn by half to two-thirds. The aim of this is to achieve an even, firm compression over the entire surface of the bandage. Any irregularities in the first layer of the bandage layer may be flattened by the second layer of the bandage. The tape stirrups are then folded back and stuck down on the bandage, these tape stirrups will assist in preventing the dressing from slipping down. If there is any excess cotton wool around the toes then this should be carefully removed and finally a protective layer of either adhesive elastic or cohesive bandage should then be applied. Ideally it is said that the finished dressing should be resonant when flicked and sound like a ripe watermelon. The central two toes should just protrude so they can be easily checked for their colour and temperature. Leaving two toes exposed also helps to encourage the patient to use the limb and allows for some weight bearing on the limb.

An alternative method of applying a Robert Jones bandage is to alternate several layers of cotton wool and bandage. Such dressings are frequently applied in various thicknesses; thicker if external support is required for a fracture or lighter if light support, to control swelling or to hold in place a primary dressing which may be placed higher up the limb. Such modified support dressings may also include splints which may be incorporated in between layers of padding material in order to prevent areas of pressure or rubbing, which may occur if the splint was placed beneath the padding layers. Sufficient padding should be placed at the proximal and distal ends of the splint to prevent trauma to the patient's skin.

Such dressings should be checked approximately 2 hours after application to ensure that the toes are not swollen. The temperature and sensation of the digits can also be assessed. If the toes do begin to swell, then the distal end of the bandage should be loosened slightly or a pressure bandage applied to the foot for 12 to 24 hours. The bandage must be kept clean and dry. The dressing should be checked regularly and may be left in place for 7-14 days.

Care should be taken that such dressings are kept dry; as the cotton wool will act as a 'wick' on contact with moisture. The owner should be made aware of this and the bottom of the dressing should be covered with a plastic bag, old drip bag or specifically made bootee whenever the animal goes outside. It should be ensured that this covering of the bandage is removed once the animal returns to a dry environment, as long-term covering of the bandage with plastic would result in major skin complications.

Head and ear dressings

The majority of head and ear dressings are placed to protect an ear that may be haemorrhaging due to trauma or post-surgery. Similar bandages may be modified to cover the patient's eye following surgery or trauma.

Placement

The ear which is to be dressed should be reflected upwards over the patient's head. Any wounds which are presents on the ear/head should be covered with a suitable sterile dressing. A pad of cotton wool should be placed on top of the patient's head, with the ear then being reflected back onto the cotton wool pad; a further cotton wool pad should then be placed on top of the ear. It may also be useful to place a further cotton wool pad beneath the patient's throat, to prevent pressure from the conforming bandage and tertiary layer. A conforming bandage should then be used to secure the bandage in place. The bandage layer should start on top of the head, passing under the chin, in a figure of eight pattern. The patient's free ear should be used as an anchor, with the bandage passing around the free ear and over the head. It may require several layers of conforming bandage in order to secure the padding. A final tertiary layer of adhesive or conforming bandage

should be placed in order to secure the dressing. If adhesive bandage is used then it may be useful to stick some of this bandage to the patient's hair in order to prevent the entire bandage from slipping forwards or backwards. A note should always be made on the bandage to show the position of the ear inside the bandage, to prevent laceration or even amputation of the pinna upon removal.

Whenever applying a head/ear bandage it is vitally important to ensure that the patient can still open its mouth and that respiration has not been impaired by the bandage being applied too tightly. It is particularly important that the adhesive layer is unwound prior to application; this is even more important if cohesive bandage is used, as if this bandage is applied under any tension, it can quickly become very tight, especially if more than a couple of layers are applied. If there is any cause for concern then the dressing should be removed and reapplied. Special care must be taken if the bandage is applied while the patient is anaesthetised, with an endotracheal tube in place, as problems may only be detected once the endotracheal tube has been removed. A correctly applied head bandage should allow for the insertion of two fingers between the bandage and the chin to allow room for neck flexion without obstructing the airway. If the bandage is too tight then an incision can be made partway across the bandage, under the chin.

If the patient is very persistent in its attempts to remove the dressing, it may be useful to extend the tertiary layer to include the cranial aspect of the chest, to prevent the removal of the dressing by anchoring it more securely around the shoulders, in a figure of eight pattern, like a chest bandage.

Tail bandage

This type of bandage is commonly applied following trauma to the tail tip, or postoperatively following amputation of the tail tip.

These bandages are commonly difficult to keep in position and can be very frustrating to place, especially if the patient wags its tail immediately following placement, and removes the dressing.

Placement

A suitable sterile dressing should be applied to any wounds. Many nursing texts advise the application of a layer of conforming bandage, covered with a layer of adhesive bandage, but the layer of conforming bandage commonly results in the slippage of the bandage, so the proximal end of the adhesive bandage should incorporate the patient's coat in order to anchor the dressing. Other techniques for tail dressings include the placement of a syringe case of a 10 or 20ml syringe barrel with the tip removed, which may then be used to cover the tail tip and can be anchored to the tail using adhesive bandage or pipe insulating material may be used to cover the tail, which again can be secured in place with adhesive bandage. This latter technique is useful as the pipe insulator is lightweight, therefore making it easier to secure the dressing in place.

Foot bandage

This is a commonly used dressing applied in an emergency to control haemorrhage and post operatively to protect wounds and control swelling.

Placement

Cotton wool or other padding material should be placed between the patient's toes and beneath the dewclaw. This padding helps to prevent pressure sores, which may arise as a result of sweat from the glands of the foot and friction between the toes. It must be ensured that the pieces of padding are not too thick, as this will make the overall dressing uncomfortable; at the same time strips must not be too thin.

Any wounds which may be present should be covered with a suitable dressing, then a padding layer should be applied over the whole of the carpus/tarsus; in foot bandages it is useful to extend the dressing as far proximally as the next joint, i.e. the carpal joint in the forelimb and hock joint in the hind limb. This technique has the advantage of preventing the dressing from slipping down; however, care must be taken, particularly in the hind limb, to prevent pressure points over the hock, which may result in ischaemic areas. The padding layer can be either cotton wool or a synthetic padding material, e.g. Soffban or Cellona. It should be ensured that the padding is applied evenly. A layer of conforming bandage for the secondary layer should be used as this conforms well to the contours of the patient's limb and is generally easier to apply than other bandages, e.g. white open weave. A final layer should be added, using a cohesive bandage, e.g. Vetwrap, or adhesive bandage, e.g. elastoplast. If adhesive bandage is used then it is useful to apply two shorter strips in a cranial to caudal, and then a lateral to medial direction; this will be useful to cover and protect the bottom of the bandage. The remainder of the adhesive bandage can then be unwound around the remainder of the foot, with the bandage being applied distally, working upwards around the limb. It is wise to unwrap both cohesive and adhesive dressings partially in order to prevent the bandage being applied too tightly.

If the bandage is being applied to control haemorrhage, the bandage can be observed to detect bleeding of the limb though the outer layers of the bandage. If this situation arises, then a further layer of padding material may be applied, covered with layers of conforming bandage and then another tertiary layer, again with the bandage being observed for further bleeding.

Thorax and abdominal bandages

Such dressings are often placed to cover wounds, surgical incisions, drains or as pressure bandages in cases of suspected abdominal bleeding. These bandages need to be applied firmly, but at the same time ensuring that there is no constriction of the chest or abdomen. When an abdominal pressure bandage is placed with the aim of controlling haemorrhage, the layers of the bandage should be applied firmly. It may be useful when removing such as bandage to do this very slowly, starting at the cranial end and making a 1 inch incision into the bandage every hour until the dressing is removed; this is generally done when there is strong suspicion of abdominal bleeding.

Placement

If a wound is present on the chest or abdomen, then this should be covered with a suitable dressing, or if a discharging drain is present then suitable absorbent material should be used in order to absorb any exudate, e.g. sterile laparotomy swab. Several layers of padding material should then be applied; this padding layer should overlap by approximately half to one-third; this should then be secured in placed with a layer of conforming bandage, and then a tertiary layer of cohesive or adhesive bandage. The dressing can be prevented from slipping backwards or forwards by wrapping the intermediate and tertiary layers between the legs and over the shoulders or hips in a crisscross fashion.

Stockinette

One type of dressing which is incredibly useful and versatile in practice is stockinette, Surgifix™. This dressing is available in several sizes but only two sizes need to be kept in stock to dress any animal from a kitten to a St Bernard (5 and 6). It is most useful for patients with thoracostomy tubes in place, as it allows easy access to the drain, but keeps all attachments associated with the drain in place, hopefully preventing accidental removal of the drain. I have also used this dressing incorporated into chest/body bandages where regular dressings may slip, or where wound dressings require to be retained in place before further dressing layers are applied.

Vacuum-assisted closure in wound management

Vacuum-assisted closure (VAC) of wounds is a treatment modality that consists of applying sub-atmospheric pressure to a wound resulting in wound protection, drainage and accelerated wound healing. Wound VAC systems are constructed by the use of commercial or improvised systems; the wound is packed with open cell polyurethane foam or gauze, covered with adhesive drape and connected with tubing to an adjustable suction device. Michael Morykwas and Louis Argenta and originally developed the technique in the late 1980s and they first published in 1997. Since that time, the use of wound VAC has grown rapidly in human medicine and is emerging in veterinary medicine.

Morykwas and Argenta initially developed the wound VAC system as an outpatient treatment option for debilitated patients with chronic wounds, particularly those with diabetic ulcers. They learned through this experience that the VAC resulted in accelerated wound closure over previous modalities. The first commercial wound VAC device (Kinetic Concepts Inc. (KCI^{TM}), San Antonio, TX) received FDA approval in 1995. Synonyms appearing in the literature for vacuum-assisted wound closure include negative pressure wound therapy; sub-atmospheric pressure wound therapy and topical negative pressure. While the term "negative-pressure" is used frequently, considering that atmospheric pressure is 760 mm Hg at sea level, a vacuum pressure of 125 mm Hg would result in a wound environment pressure of 635 mm Hg. Therefore, application of vacuum to a wound creates a wound environment of sub-atmospheric pressure and not truly negative pressure.

Morykwas and Argenta first published data for the clinical use of VAC in 1997 and they claimed that VAC accelerated wound healing by increased wound perfusion, wound drainage and bacterial clearance allowing wound closure with reduced operative episodes. In their initial theory, they hypothesized that VAC functioned through a fluid-based mechanism in which negative pressure reduced interstitial pressure and opened capillaries in and around the wound resulting in increased blood flow. Removing fluid from the wound decreases oedema and shortens distance for diffusion of substrates, further reducing interstitial pressure. The negative pressure draws fluid through the wound removing wound healing inhibitors, such as matrix metalloproteinases and bacteria, and helps attract wound healing growth factors, such as transforming growth factor β-1, vascular endothelial growth factor and platelet derived growth factor, among others. Vacuum-assisted wound closure removes fluid containing both positive and negative factors from wound, but the balance leans toward removal of negative factors and accelerated wound healing in many circumstances.

Subsequent research indicates that mechanical deformation of tissue plays a substantial role in accelerated wound healing with VAC. The skin and other soft tissues demonstrate viscoelastic properties, termed mechanical creep, that allow it to stretch and proliferate under mechanical stress in the same mechanism that allows bone growth with distraction osteogenesis or skin to grow with tissue expanders. Granulation tissue is reported to survive under conditions of 100% deformation; cadaver studies indicate the wound tissue undergoes 18% deformation and peri-wound tissue up to 8 cm undergoes 5% deformation. This indicates that a significant amount of peri-wound tissue is recruited with the beneficial tissue strain of wound VAC. The stretched cells and tissue not only physically expand to shrink the wound, but undergo increased mitosis and rapidly create new tissue to fill the wound. The mechanical strain resulting in cell deformation induces a variety of cellular changes including altered permeability, gene expression and release of second messengers to effect wound healing.

Research has utilizing pressures from 25–400 mm Hg demonstrated that 125 mm Hg is the ideal pressure to apply to a wound to maximize tissue perfusion and tissue proliferation. Vacuum options include continuous and intermittent pressure. Doppler studies revealed that perfusion returned

close to baseline levels five to seven minutes after the onset of vacuum and peaked again when vacuum pressure resumed. Subsequent devices facilitate intermittent vacuum with five-minute vacuum cycles and two-minute intermissions.

Some of the reported indications for wound VAC in the human literature include the following: envenomation, extravasation of chemotherapeutic agents, skin grafts, flaps, burns, a wide array of chronic wounds, complicated acute wounds or in patients with comorbidities, open abdomens, fascial compartment syndrome, enterocutaneous fistulas, degloving injuries and open fractures. It is also been described over the incisions of high-risk closed wounds. VAC in open wounds is particularly useful in accelerating the rate of granulation tissue formation and drawing the wound edges closer together. VAC application over skin grafts and flaps helps to minimize graft/flap movement, eliminate oedema under the graft/flap and accelerate the inosculation of graft/flap vessels and tissue-bed vessels. Reported complications include the following: pain, infection, toxic shock syndrome, wound desiccation (inadequate seal), pressure necrosis around suction tube, foreign body granuloma, tissue in-growth into the sponge, fatal haemorrhage, skin graft/flap disruption and cardiac graft rupture. Contraindications in humans to vacuum-assisted wound closure include the following: malignancies, coagulopathies, untreated osteomyelitis, unprotected vessels, nerves or viscera, non-enteric fistula to an organ or body cavities, certain psychiatric patients.

The use of vacuum-assisted wound closure has increased substantially in human medicine and is emerging in veterinary medicine. In human studies and research models, VAC has demonstrated benefits over wet-to-dry bandaging as well as many modern wound dressings in accelerated granulation tissue formation, decreased time to definitive wound closure and decreased complications. The United States military has gained a wealth of experience in treating combat injuries with wound VAC in recent years and witnessed a substantial reduction in post-operative wound complications since implementation. In particular, they experienced reduced operative episodes, reduced infection, reduced dehiscence, and a higher percentage of graft and flap survival. Appropriate initial wound management is essential for the effective use of VAC. Chronic wounds should be debrided and converted to an acute wound before VAC application. Application of a wound VAC to an ischemic wound reportedly induced tissue necrosis. Dirty or contaminated wounds should be converted to clean-contaminated wounds by the appropriate combination of lavage, debridement and wet-to-dry dressings or other wound dressings before applying a wound VAC system. Vital structures such as nerves, vessels and viscera should be covered with tissue flaps or polyvinyl sponge to avoid damage from the foam. The reported frequency of bandage changes with VAC range from one to up to five days. In general, 48-hours seem to be the maximum time advised between bandage changes. Intervals of more than 48 hours allow more tissue in-growth in the sponge and result in increased pain and bleeding at sponge removal as well as an increased likelihood of dislodging foam fragments into the wound. Anytime there is a loss of suction on the wound, the cause must be corrected immediately to avoid wound desiccation.

Vacuum-assisted wound closure is an excellent tool in human and veterinary medicine for dealing with complicated wounds and wounds in patients with co-morbidities. However, it is not a substitute for initial diligent wound management. Authors have expressed concern in human medicine for the over-use and inappropriate use of vacuum-assisted wound closure when traditional methods are indicated. As we learn more about the appropriate indications and techniques for veterinary medicine, it shows great promise for an expanded role in the future.