Surgical wound management

Surgical wounds are those created intentionally by a surgeon for the direct treatment of a condition or to allow access to deeper anatomy for a procedure to be performed. The term ‘surgical incision’ might better describe most elective procedures, as a wound is also used to describe a nonintentional accidental injury (or worse, an intentional malicious one!). Surgical sites heal by the application of one of, or a combination of, approaches:

Primary closure – immediate closure of the incision; the vast majority of elective procedures

Delayed primary closure – surgical closure before the presence of granulation tissue, having managed the wound open for hours to days

Secondary closure – surgical closure over granulation tissue

Second intention healing – leave wound healing to proceed normally without further surgical intervention, encouraging conditions that favour uncomplicated healing in a normal timeframe.

The vast majority of surgical incisions closed primarily heal without any problems. In particular, those created to access underlying anatomy (e.g. the musculoskeletal system, abdominal viscera and thoracic organs) that do not involve excision of cutaneous tissue have a very low complication rate. The most common complication is probably infection, which will affect approximately 2-5% of elective procedure.

Application of delayed primary, secondary closure and second intention healing are most commonly used for traumatic wounds, or complications of surgical incision or reconstruction dehiscence.

However, elective delayed closure or second intention healing can be used in some rare situations (e.g. closure following histopathological confirmation of tumour diagnosis / completeness of excision, second intention healing following tumour excision in awkward locations.
Normal healing
Incisions and soft tissue wounds undergo several phases of healing, each merging seamlessly into the next. These are classified as:

Coagulation (clotting) phase

Inflammatory phase

Proliferative (or healing) phase

Maturation (or reorganisation) phase

Coagulation begins immediately in healthy animals. Blood vessels first spasm and contract to limit bleeding, but later dilate to provide oxygenated blood and allow neutrophils to reach the area. A platelet plug forms (primary haemostasis) limiting contamination and blood loss. Later, this seal is strengthened and reorganised as a result of the action of clotting factors (secondary haemostasis) to add fibrin and later collagen.
**The Inflammatory Phase** also begins immediately post-injury and should last approximately 3-5 days. Neutrophils dominate this phase and are important in removing necrotic material and protection from invasion by microorganisms. Inflammatory mediators released from leukocytes and damaged cells attract and activate circulatory cells important in the next phase of healing.

**The Proliferative Phase** is characterised by the presence of granulation tissue and beings from about days 3-5 post-injury, lasting for approximately 3 weeks. Healthy granulation tissue has a rich red appearance and a velvet smooth matt finish. It contains fibroblasts (collagen producing cells), a developing collagen matrix which is important for wound strength, macrophages and developing blood vessels. As it matures, myofibroblasts produce myocollagen that results in wound contraction. This can lead to a 30% reduction in wound surface area in loose skinned areas, with maximal contraction about 7-10 days after injury.

Healthy granulation tissue is very resistant to infection and provides a foundation for epithelial cells (skin cells) to migrate from the wound margins across its surface. Sutured wounds with a small dermal gap epithelialise in 48hrs since there is no intervening proliferative phase. Epithelialisation of open wounds begins 4-5 days post-injury and may take weeks to complete. Epithelialisation produces a fragile hairless scar compared with normal skin.

**The Maturation Phase** begins 2-4 weeks post-injury. Remodelling of collagen confers strength to the tissue (up to 80% of original strength for skin). Fibre orientation parallel to tension in the tissue allows it to better resist lines of force. This can continue for months to years after an injury, depending on the tissue type and the forces acting on it.

Cats are different to dogs. Compared to dogs, they have a poorer blood supply to the skin, a weaker inflammatory response, a slower increase in wound strength as they heal, slower development of granulation tissue and finally slower epithelialisation.

**Fundamentally, the aim of all wound management is to allow healing to proceed normally OR speed up the healing process.** For all types of wound, we should avoid doing anything that slows healing and try to encourage a wound environment that facilitates transition from one healing phase to the next.
Complications of healing

Broadly speaking, problems with all types of wound healing arise from:

factors related to the wound

factors related to the patient

factors related to the surgery / surgeon.

Alternatively, we can subdivide potential causes of complications according to:

**Mechanical factors** e.g. tension, patient movement, dead space

**Local biological factors** e.g. infection, ischaemia, tissue hypoxia

**Systemic biological factors** e.g. hypoproteinaemia (e.g. protein losing disease, inappetance), metabolic disease (e.g. hyperadrenocorticism, diabetes mellitus, hypothyroidism), immunocompromise, coagulopathy, anaemia, neoplasia, uraemia, infectious agents (e.g. FeLV / FIV).

This webinar and accompanying notes is focused on complications with surgical incisions leading to wounds. Factors related to the surgery and surgeon are therefore of particular relevance; careful planning to minimise mechanical factors contributing to dehiscence, good technique maximising the local biological environment and thorough patient investigation prior to surgery to then recognise and manage/treat systemic disease will reduce the incidence of (but never eliminate) incision complications.

Wound complications as a consequence of surgery

Inappropriate surgery or poor technique can increase the incidence and severity of wound complications. Application of Halsted's principles will reduce the risk of incisional complication:

**Gentle tissue handling (avoid crushing, use sharp dissection)**

Rough tissue handling of the skin and subcutis will lead to local vasospasm and tissue hypoxia

Crushing skin margins can lead to vessel damage and ischaemic necrosis

**Accurate tissue apposition**
Poorly closed skin incisions will allow commensal skin bacteria to colonise the incision

Minimise dead space

Seroma formation can potentiate infection (bacterial culture medium), put tension on the incision and lead to local hypoxia with consequent delayed healing.

Use of drains (closed active drains preferred over Penrose) will eliminate seroma formation in the first few days after surgery.

useful if considerable dead space is present

useful in exudative location to prevent discharge through the incision and allow a fibrin seal to form in the first couple of days. If there is fluid discharge from an incision, then there is a route for superficial skin bacteria to enter the underlying tissues.

once the drain is removed, if the dead space has not closed down internally with a decent fibrin seal to the underlying tissues, then a seroma may just reform (more likely if >4.5ml/kg/day fluid is being produced at the time of closure), but at least the incision will have had time to seal against bacterial contamination.

the longer a drain is left in place, the higher the risk of ascending bacterial infection. Use gloves when managing the drain, dress the drain exit site and assess/clean the area daily.

Avoid tension on closure

Careful planning is paramount. Clip and drape widely prior to a procedure, and have several reconstruction options available prior to the first cut. Spend time pulling the skin of the animal around and making careful measurements.

Detailed consideration of surgical reconstruction techniques is outside of this webinar remit, but seek further guidance from books or specialists if you are not comfortable with complex techniques and you are creating a large hole that will not close without excessive tension on the skin margins with simple primary apposition (and assuming appropriate peripheral undermining is performed to relieve tension).
Accurate and meticulous haemostasis

Postoperative haematoma formation increases subcutaneous dead space which will mechanically disrupt the incision edges and provides a bacterial growth media.

Haemaglobin and the physical presence of the clot also impedes the action of phagocytic cells.

Excessive use of electrosurgery or sutures will increase foreign material and can act as a nidus for infection and so they should be used as needed but judiciously.

If a haematoma or incisional bleeding develops immediately postoperatively, direct pressure using a cold pack can be extremely effective. Depending on the location, a dressing can be applied to maintain pressure afterwards (taking appropriate precautions to remove / replace the dressing if it is initially placed tight to avoid vascular compromise). Sedation of patients to limit excessive movement can be useful if this would not pose a risk to the animal. Always consider the possibility of coagulopathy, which may require further investigations to confirm and subsequent treatment (e.g. desmopressin, cryoprecipitate, fresh frozen plasma etc). Surgical intervention may be required if there is considerably arterial bleeding, no response to topical interventions with normal coagulation, secondary effects of the space occupying nature of the haematoma (e.g. compression of the airway with a neck swelling), developing dehiscence / necrosis / secondary infection.

Preserve tissue blood supply

Observe strict asepsis

Scrubs, sterile closed gloves over long sleeve gown, good theatre protocols

Surgical procedure time should be as short as possible. Prolonged surgery (approx. >90 minutes) or anaesthesia (approx. >120 minutes) is associated with increased incision infection rates.

Perioperative antimicrobials are reserved for long surgeries / GA, those where permanent implants are placed and those where infection would be catastrophic (e.g. total hip replacement). Clean procedures do not require periop antibiotics, but clean-contaminated (open luminal viscera with no spill) or contaminated (spillage of contents / break in aseptic technique) arguably do. Broad spectrum intravenous drugs are most sensible (e.g. amoxiclav, cefazolin, cefuroxime) given every 90 minutes.
This is not the same as postoperative antibiotics, which are given as a treatment course over the next few days and for which there are different considerations.

**Dehiscence and infection**

Wound dehiscence can occur hours to weeks after a surgery. Opening of the incision margins, often with a discharge (purulent or serosanguineous) from the resultant wound, is generally observed, with or without associated inflammation and/or tissue necrosis. The presence of small volumes of pus does not necessarily mean that the wound is infected, although it is sensible to start broad spectrum antimicrobials whilst culture and sensitivity results are pending.

Incisional opening within a few hours may be more associated with poor surgical technique, patient interference or considerable movement at the wound location. Incisional dehiscence with ischaemic necrosis tends to be seen 5-7 days after surgery. If a reconstructive flap has been performed, this is usually seen at the flap tip. Avoiding tension on closure and trying to avoid making the flap too long (since survival of the flap depends on perfusion to the end through the subdermal plexus) helps reduce this risk. Larger flaps can be raised with more consistent survival by using axial pattern flaps, directly supplied by direct cutaneous arteries. However, even then, some axial pattern flaps are more robust than others (e.g. caudal superficial epigastric and thoracodorsal possibly more reliable than omocervical and reverse conduit flaps). Sometimes, it is not possible to prevent some movement (and therefore intermittent tension on the incision) or dead space under a flap (e.g. facial reconstruction following large maxillectomy procedures) which can increase the risk of dehiscence.

Infection of an incision (most commonly a presumptive diagnosis based on incisional inflammation beyond the initial inflammatory period, although best diagnosed by culture and sensitivity) is considered a surgical site infection (SSI) if it occurs in the 4 weeks after a soft tissue procedure, and within a year if there is a permanent implant placed (e.g. orthopaedic surgical implant, polypropylene mesh).
Initial investigation and management

The animal should be completely assessed to identify which contributory factors (mechanical, local and patient) may be involved, and the underlying causes dealt with if possible.

Serum biochemistry and haematology if there is not a clear reason resulting from an error in surgical technique or wound location (e.g. excessive tension, ischaemic necrosis 5-7 days after a reconstructive flap surgery, animal chewing on surgical site, incision over a pressure point or highly mobile area (foot pad / joint))

Wear gloves! – not necessarily sterile

Pay attention to the peri-wound

Widely clipped

Clean skin with dilute chlorhexidine (or similar) as for surgical skin preparation

Cover tables with incontinence sheet / paper towel / clean towel

Lavage dry wounds / superficial contamination from the surface of wounds; sterile Hartmanns solution, a fluid bag, giving set, and a 3 way tap with a 20ml syringe and 21G needle;
or, 21G needle connected to the giving set directly and a pressure infusion cuff on the fluid bag, inflated to the maximum pressure

Consider collecting swabs/tissue samples for bacteriology; start antibiotics after sample collection, and choose a broad-spectrum drug until culture/sensitivity results are obtained (e.g. potentiated amoxicillin).

Sharp surgical debridement if required (preserve tendons / ligaments / nerves).

Dress wound according to requirement i.e. debriding dressing versus protective dressing to encourage the current / next stage of wound healing. Dressing materials will be discussed in the next webinar by Georgie Hollis. Some considerations other than material choice include:
Bandage or tie over dressings can be used to cover difficult locations. Suture loops are placed circumferentially around wound, with the contact layer secured over the wound and compressed on to the surface using sterile swabs/pad with suture/tape laced over the top and tied securely).

Consider further support e.g. splint.

Buster collar

Consider biopsy of the wound, particularly if it appears relatively healthy, is not healing despite appropriate treatment and is potentially at the site of a previously excised neoplastic process.

**Debridement**

If an area of tissue is becoming necrotic, staged surgical debridement is sensible; removal of obviously necrotic tissue during a dressing change, whilst preserving tissue that may or may not survive over the next few days. Removal of dead tissue and debris is vital for progression of normal wound healing. This can be performed by:

- Sharp selective surgical removal of dead or contaminates tissue, being careful to preserve vital anatomy (nerves, tendons, ligaments).
- Mechanical debridement using dressings (e.g. wet-to-dry) to tear off debris and dead tissue that sticks to the dressings when changed. This is non-selective, but very effective, particularly for small particulate debris.
- Autolytic debridement, using dressings to maintain a moist environment that facilitates the bodies natural debridement process, and lavage away the debris during dressing changes
- Enzymatic (rare); proteolytic enzymes applied to the wound surface.
- Biosurgical (uncommon): Biological grade maggots, 5-8 per cm² that remove necrotic tissue, disinfect wound & promote granulation tissue
Negative Pressure Wound Therapy (NPWT)

This relatively recent wound treatment modality is gaining popularity and is extremely effective in encouraging rich healthy granulation tissue and removing fluid from exudative wounds. Controlled negative pressure is continuously applied to a wound (between -80 and -125mmHg) using a vacuum device, a sterile foam primary contact layer and an airtight plastic film covering. The dressing is in place for at least 3-5 days and generally a maximum of 7 days. Benefits include reduction in wound oedema (and therefore improved oxygen supply to tissues), removal of exudate, a suspected reduction in tissue levels of bacteria, more rapid and more richly vascularised granulation tissue formation. They can delay epithelialisation and contraction if used longer than 7 days.

Plan for final closure

Every time the wound is assessed, consider changing the management if the area is not looking progressively healthier. Also, assess the surrounding tissue for laxity and changes, considering how one might perform surgery and what spare tissue is present. Once the wound is completely healthy, final closure can be achieved using further surgery (primary apposition or more advanced reconstructive techniques) or by second intention healing. It is not uncommon for us to treat reconstructive flap ischaemic necrosis and consequent dehiscence by second intention healing. A surgical complication does not necessarily require a surgical solution. Dressing choices to encourage second intention healing will be discussed in the next webinar.

Surgical reconstruction once the wound is healthy can be quicker, more cost effective and produce a more satisfactory functional and cosmetic outcome than second intention healing once the wound is healthy. For example, for large wounds where second intention healing would be slow, result in thin epithelium susceptible to trauma (e.g. distal limbs), result in functional problems (e.g. contraction over joints, contraction affecting external orifices) or result in poor cosmesis. Methods of surgical closure can include:

Tension relief and primary closure

Subdermal plexus flaps

Axial pattern flaps

Free skin grafts
Bearing in mind that cats have slower granulation and epithelialisation of wounds than dogs, consider surgical management of open wounds in cats sooner than one might for dogs.

**Delayed healing / chronic wounds (treated as second intention)**

Failure or prolongation in any phase of wound healing may result in a delay or ultimately failure of wound closure. It is therefore important to recognise what phase of wound healing is present, whether the wound has been in that phase for too long and then investigate (and treat!) the reasons causing an arrest in healing. Problems may be best recognised by:

- Booking the patient in with the same nurse/vet at least once weekly
- Taking photographs at each recheck or having the owners email photos
- Taking time to evaluate progression of healing and keeping accurate records

1) Prolongation of the inflammatory phase can result from:

   - Infection
   - Foreign material
   - Desiccation
   - Excessive exudate and tissue maceration
   - Necrosis of superficial layers of tissue
   - Continuing tissue damage (self trauma, abrasion)

Action should then be taken to deal with these possible causes:
Eliminate infection:

Culture/sensitivity

Systemic antibacterial therapy

Topical antibacterial therapy, Silver or Honey

Complete debridement, using dressings and/or surgery

Improve wound hydration if desiccated (e.g. occlusive dressings, hydrogels)

Remove excess exudate, using more absorbent dressings (e.g. Allevyn, sterile nappies) or NPWT

2) Failure/prolongation of proliferative phase can be recognised by the appearance of chronic indolent granulation tissue; this has an irregular, pale pink lumpy surface that doesn’t bleed when disturbed and can look slimy. Discount causes such as abrasion/trauma, desiccation and continued damage from chemical irritation (e.g. urine scald). Non-healing wounds are characterised by a percentage area reduction of <20-40% over a 2-4 week period of treatment.

Use a scalpel blade to freshen up surface/edges

Re-stimulate the granulation tissue (Wet-dry dressings or alginates). This may require hospitalisation for several days.

Protect the wound and maintain a moist environment (Allevyn and tie-over dressings)

Consider reconstructive surgery

Consider using NPWT (one of the earlier things I would now consider)
INVESTIGATE

Systemic health evaluation

Infection (bacterial, fungal, mycobacterial)

Histopathology +/- special stains for neoplasia

Solving the problem can therefore include:

Deal with underlying factors as best as possible

Treatment of systemic disease (e.g. Cushing’s or hypothyroidism)

Vitamin A (particularly if receiving steroids)

Eliminate infection

Address physical factors

Explore different techniques

Summary

Careful surgical planning and good technique can avoid most incisional complications. However, the more complex surgeries and difficult locations will always carry a higher complication rate and risk of dehiscence. Breakdown due to errors in technique should be recognised and learned from. Second intention healing can be an effective method to deal with incisional wounds and a good understanding of the biological processes involved, accurate recognition of the stage of wound healing and early identification with appropriate treatment of problems can dramatically accelerate closure. Surgery can result in earlier closure and better functional result in some cases, but only following appropriate early management of the wound to ensure that it is healthy. Considering the whole patient and close owner communication is vital for a successful outcome.