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Practical Wound Management for Nurses Mini Series

Session 3: Wound Closure, Reconstruction and Infection Control

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Post-operative wound infection is a common and potentially serious complication of surgery. The effect can range from minor, quickly resolved infections, to serious life-threatening illnesses that can be difficult and expensive to manage. Such situations are crucial for the patient and can strain relationships between surgeon and client to the limit. Approximately 5% of small animals that undergo surgery develop infection despite the measures taken to minimise contamination and use of antibiotics. Increasingly sophisticated anaesthetic protocols and surgical expertise has resulted in larger numbers of more complex procedures being performed on patients with significantly reduced ability to combat post-operative infection. This, along with the increased prevalence of resistance among populations of micro-organisms, has placed even greater emphasis on the design of and adherence to strict surgical asepsis protocols. The principle of surgical asepsis is the complete exclusion of micro-organisms from the surgical wound. However, the reality is the effective use of complementary equipment and protocols at many levels designed to reduce the level of contamination to levels that the host's defences can control.

Wound contamination

All surgical wounds become contaminated with bacteria, but not all become infected. A critical level of contamination is required before infection occurs, often quoted as approximately 10^5 organisms per gram of tissue or ml of fluid. However, this oversimplifies the situation somewhat since there are many factors involved in determining whether a level of contamination within a wound will result in infection. These factors relate to the host's resistance, the characteristics of the contaminant organism, and the interaction between host and contaminating micro-organism (i.e. the local wound environment).

Bacterial inoculum

- Number of bacteria
- Virulence
- Time since contamination

Impaired host defences

- Old age
- Poor physical condition
- Malnutrition
- Systemic disease
- Drug therapy

Local factors

- Necrotic tissue
- Haematoma
- Dead space
- Reduced blood supply
- Foreign material

Definitions

Surgical infections – wound infections that develop at the operative site within 30 days of surgery or within one year if implants are placed.

Sepsis – presence of pathogens of their toxic products in the tissues of a patient

Asepsis – absence of pathogenic microbes in living tissues

Antiseptic – agent that either kills pathogenic micro-organisms or inhibits their growth whilst the two remain in contact. Term reserved for agents that are applied to the body.

Disinfectant – germicidal chemical substance, that kills micro-organisms on inanimate objects

Disinfection – removal of micro-organisms but not necessarily their spores.

Sterilisation – complete elimination of microbial viability, including both vegetative forms of bacterial and spores. Physical and chemical means

PATIENT SELECTION

In order to assess the risks of surgical wound infection, a full evaluation of each patient for suitability for surgery should be carried out. This will guide the pre-operative preparation, the anaesthetic risks and protocol, the surgical procedure used, and influence the post-operative care of the patient. Important considerations include the patient's physical condition, the presence of intercurrent disease and the presence of remote sites of infection.

TYPE OF SURGICAL PROCEDURE

Clean

Clean-contaminated

Contaminated

Dirty

SOURCES OF CONTAMINATION

Most bacterial contamination occurs at the time of surgery. Consequently, the peri- and intra-operative phases of patient management are regarded as mainstays of aseptic technique. The main sources of contamination in surgery are:

- The patient
- Surgical equipment
- Theatre environment
- Surgical team

THE PATIENT

The most common source of contamination is the patient's endogenous microbial flora. The skin and the hair of the animal harbour significant numbers of endogenous (normally present) and exogenous (environmental contaminants) bacteria. Common **endogenous** canine skin flora include *Staphylococcis, Micrococcus, Streptococcus, Actinobacter, Clostridium,* and *Bacillus* species as well as some Gram negative bacilli and diphtheroids. The range of **exogenous** bacterial present will of course depend on the animal's environment and will vary between patients.

PREOPERATIVE ANTIBIOTICS

This is a different concept from treatment of infection with antibiotics. The aim is to have effective levels of a suitable antibiotic in the tissues at the time of surgery and for approximately three hours after surgery whilst the wound's fibrin seal forms. This will mean administration before induction, usually by intravenous route, and is designed to prevent the inevitable contaminants from establishing even a low level of infection. Repeat doses may be necessary depending on the length of the surgery and the antibiotic used. With appropriate use, there should be no need for post-operative courses of antibiotics for clean and clean contaminated procedures. Routine treatment of all surgical patients with a course of antibiotics is acceptance that infection is likely and therefore aseptic technique is unacceptably inadequate. Each case should be considered carefully and the many factors involved (e.g. length of surgery, implant placement, breaks in sterility, classification of cleanliness of surgery etc.) taken into account before antibiotics are dispensed.

HAIR REMOVAL

Hair removal is required for the majority of surgical procedures and may be carried out before anaesthesia is induced to reduce the anaesthetic duration and reduce the number of loose hairs present at surgery. However, removal of hair following induction is usually quicker and easier especially in the face of discomfort. Unfortunately all methods of hair removal will cause some degree of skin damage which will result in rapid bacterial colonisation. The incidence of post-operative surgical infection increases with the time interval between hair removal and surgery. Therefore, it is best removed immediately before surgery. Shaving is no longer recommended as it has been associated with up to a 10 fold increase in post-operative surgical infection. It minimises stubble but causes multiple small lacerations and skin erosions. Clipping is the recommended method of hair removal. Sharp blades, ample lubrication and coolants all minimise skin trauma. The blades should be cleaned between cases and sterilised if necessary. The clipped area should include 15cm each side of the proposed incision site and all sites clipped simultaneously in the case of multiple procedures. Unless directly involved in the procedure, paws should be covered with an impermeable material instead of clipping. Wounds may be covered with saline soaked gauze swabs or sterile water soluble gel to minimise hair and dander contamination during clipping.

SKIN PREPARATION

The patient's skin cannot be completely sterilised, so the aim of preparation is to minimise the bacterial numbers whilst avoiding skin damage. Surgical scrub solutions contain both antiseptic and detergent components. The physical activity of skin preparation will loosen and remove organic debris (aided by detergent) and kill the transient or exogenous bacteria (aided by the antiseptic component). The levels of endogenous bacterial may be reduced but during the procedure they come to the surface from the skin from the follicles etc. and are a source of contamination. It is for this reason that

a second antiseptic solution (water or alcohol based) should be applied to give residual surface bacterial activity. Both povidine-iodine and chlorhexidine are widely used and are generally considered to be equivocal in bacterial kill rates and incidence of postoperative wound infection. The use of either agent is justified though chlorhexidine has the advantage or prolonged residual activity, continued activity in the presence of organic matter and reduced incidence of skin reactions. It is important to note that Gram-negative bacterial (e.g. *Pseudomonas* spp) can live and multiply in some dilute antiseptic solutions so each solution should be freshly dispensed into sterile containers from concentrated stock solutions and any unused diluted preparation discarded after 48 hours.

DRAPING THE PATIENT

Draping maintains asepsis by preventing contamination of the surgical field by hair and the immediate environment. The drapes should cover the entire patient and table with only the surgical site exposed. The ideal material would be easily sterilised, economical, and maintain its barrier properties. It must be securely fastened to the patient during surgery. Both reusable and disposable drapes are available.

SURGICAL EQUIPMENT

It is essential that all instruments, implants and equipment used in the surgical procedure are sterilised before use. There are several different methods available and the choice of method used will depend on the amount and type of equipment to be sterilised, financial considerations and available space for the equipment. Each method has its own advantages and disadvantages. Failure of sterilisation usually results from inadequate maintenance of equipment, or modification of the protocols without careful consideration.

CLEANING

Regardless of the technique to be used, gross contamination must be removed before sterilisation if it is to be effective. Cleaning items immediately postoperatively is ideal, by initially rinsing under cold water (hot water causes protein denaturisation leaving adherent residues) or soaking in detergent solution pending final cleaning. Abrasive cleaning products and ordinary soap should be avoided (this leaves behind an insoluble film). Ultrasonic cleaning devices are very useful, cleaning by a process of microcavitation.

STEAM CLEANING (autoclaves)

Sterilisation with saturated steam under pressure is the most dependable and widely used method of microbial destruction. Steam penetrates each pack and porous article, giving up heat as it condenses. It depends on direct contact and so items impenetrable by the steam are unsuitable for this method as are heat sensitive items. Air present in the steriliser will reduce the penetration of the steam and limit the condensation as well as the attainment of the high temperature necessary. Modern steam sterilisers differ principally in the mechanism by which air is excluded during the procedure.

- **Pack preparation** – items are packed according to their intended use and arranged to allow full steam penetration. Complex items should be disassembled and locking mechanisms should be open. Dishes should be placed in the chamber in rows so they are parallel to the

flow of the steam. Care should be taken to avoid overloading and blocking of the inlet and exhaust valves.

- **Autoclave operation** – it is generally agreed that 13 minutes at 120°C is a safe minimum standard to destroy most resistant microbes. Emergency sterilisation is carried out at 131°C for three minutes. The cycle times will be longer to account for heat up and dry times.

MOIST HEAT (boiling) Boiling cannot be guaranteed to kill all micro-organisms and their spores as the maximum temperature attained is 100°C. Therefore is should not be considered as a means of sterilisation.

DRY HEAT Dry heat kills micro-organisms by causing oxidative destruction of bacterial protoplasm. Equipment suitable for this method is restricted to those not easily damaged by the conditions. Hot air ovens have largely been superseded by autoclaves.

IRRADIATION Gamma radiation is the most effective, and enables a measured dose to be administered easily. Many pre-packaged items (e.g. needles, syringes) are sterilised in this way.

ETHYLENE OXIDE Ethylene oxide inactivates cellular DNA and prevents cell reproduction. It is capable of destroying all known bacteria, spores and the larger viruses but it is toxic, irritant to tissue and flammable unless mixed with carbon dioxide. The only system available in the UK operates at room temperature and takes 12 hours, it is suitable for many items but its use is limited by the size of the sterilising chamber, its toxicity and the time needed. There are strict health and safety regulations regarding its use.

COLD STERILISATION - This refers to the soaking of items in disinfectant solutions ad should be considered really as disinfection although some manufacturers guarantee sterilisation after 24 hours. Occasionally used for endoscopes and other items unsuitable for steam sterilisation, this method should not be used for items that may be introduced beneath the surface of the body.

GAS PLASMA Hydrogen peroxide gas plasma sterilisation results in rapid inactivation of a broad spectrum of micro-organisms and removal of harmful residues. It takes approximately one hour and requires no aeration. There are no reported toxic emissions or residues. Specialist equipment is required.

Theatre environment

The design, construction and layout of the operating theatre, as well as room protocols will affect how readily the principles of aseptic technique can be applied.

Design

It is important to minimise traffic through the operating room both in terms of personnel and patients. Only patients undergoing surgery should enter the room, having been previously anaesthetised and prepared for surgery. The room should have good access but be away from the main thoroughfares in the practice with only essential, correctly attired personnel being allowed entry. The room must not be

used for other purposes. The room should be of suitable size for the surgical team and equipment but small enough to facilitate regular thorough cleaning and discourage storage of redundant equipment. The air should flow from the area of least contamination towards other areas. Therefore the operating room should be at mid positive pressure with at least 25 air changes per hour if the air is re-circulated or 15 if it is vented to the outside. Fan heaters should be avoided since they cause dust and air movement. The floors and walls should be light coloured, non-staining, seamless and impervious with coved corners to facilitate thorough cleaning. Furniture should be minimal, and what there is should be ideally simple construction stainless steel and glass. A pass through port from the preparation room is extremely useful as it minimises traffic.

Use

Surgeries should be ordered from the cleanest to those with the potential for contamination being performed last. A surgical list should allow any occurrences of sepsis to be traced. Dirty procedures (e.g. dentals) should be performed in a separate room allocated for such procedures.

Maintenance and cleaning

This is essential if high standards of asepsis are to be achieved. Before commencing the surgical list each day the surfaces should be damp dusted (not dry dusted as this merely moves the dust) with a dilute disinfectant solution. Between cases the table, equipment, and floor if soiled, should be thoroughly cleaned and disinfected. All surfaces should be scrubbed and cleaned with disinfectant. Each week there should be a thorough cleaning session when all equipment is removed from the room and all walls, ceilings etc. scrubbed with a disinfectant solution that also has detergent properties which will remove organic debris and is active against a ranged of contaminants, including *Pseudomonas* spp. All equipment should receive similar meticulous cleaning. Operating room cleaning utensils should remain exclusive to this room and be stored separately, away from the sterile area.

The surgical team

Preparation of the surgical team is aimed at minimizing contamination through the shedding of particulate matter (including micro-organisms).

Scrub suits

An occlusive barrier to micro-organisms, these garments should not be worn outside the operating theatre or for procedures where contamination is possible if further surgery is planned.

Surgical head covers

These are the most useful item as hair represents a primary source of contamination from the surgical team. Hoods are preferable to caps and the item chosen must cover the occipital and temporal regions.

Shoes

The wearing of designated theatre shoes appears to be no more effective at reducing bacterial contamination than properly fitting covers over outdoor shoes. Uncovered outdoor shoes should not be worn in the operating theatre.

Face masks

Face masks do reduce the level of environmental contamination since droplets shed are directed to the sides and bottom of the mask. Indeed, during quiet talking and breathing there is little of no emission of bacterial laden particles. However, masks do protect the wound from droplets of saliva expelled during talking. Those that pass through the pores are of a size that does not readily fall into the wound. Masks will also tend to reduce unnecessary chatter in the operating room.

Scrubbing up

Similarly to patient preparation, scrubbing is aimed at the mechanical removal of gross organic debris and transient flora and killing the resident population of bacteria. No single technique has been found to be superior; therefore one method should be selected and strictly followed. Present opinion recommends a technique of approximately five minutes duration for the first case or following contamination, and three minutes for subsequent cases. The hands should always remain higher than the elbows, with particular attention paid to nails, cuts and abrasions. Storing brushes in antiseptic solution will allow some bacteria to multiply freely and become transferred to the patient by the surgeon and so this practice must be avoided by using either autoclaved or sterile disposable brushes instead.

Gloves

Gloves may be considered a sterile barrier and should be worn to reduce contamination still further. Closed gloving technique is preferred. Studies have shown that most gloves develop minor perforations by the end of the procedure though with good routine skin preparation this does not increase the likelihood of wound contamination. Double gloving is recommended for orthopaedic cases.

Gowns

Gowns also represent a sterile barrier between surgical team and patient. Gloves should cover the elasticated cuff of the gown.

Surgical technique

The technical skills of the surgeon are also important in reducing the potential for infection. By the close observation of Halstead’s principles of atraumatic, aseptic surgery, tissue contamination and injury are minimised. This will result in the preservation of vascularity, tissue oxygenation and enhancement of wound healing. The elimination of dead space will also significantly reduce the infection rate, as well as the placement of minimal numbers of finest appropriate gauge sutures. It is important to minimise the length of surgery as far as possible since for every hour of surgery, the infection rate is approximately doubled.

POST-OPERATIVE PATIENT CARE

The principles of asepsis should be carried through into the post-operative period with regard to sterile dressing changes and the maintenance of catheters and drains. Reduced attention to detail at this stage may reduce the benefits of the measures taken pre- and intra-operatively to avoid contamination. The potential for contamination with nosocomial infection has been found to be directly related to the length of stay in the hospital environment and the number of procedures (from catheter placement to radiography) that the patient undergoes.

SUMMARY

In combination with aseptic operating technique, the principles and protocols outlined in this article should allow the highest standards of surgical asepsis to be sought and maintained. Whilst adaptations to accommodate facilities available, operator preference and economics are often necessary, the pursuit of excellence must be continued since failure to observe these principles may have disastrous consequences on the outcome of surgery.

Suture Materials and Wound Closure

Introduction

We see a large variety in the type of wounds our patients present with in veterinary practice. For example lacerations, burns (thermal, caustic or electrical), puncture wounds, bite wounds, firearm injuries, shearing injuries and de-gloving wounds. No one method can be applied to the management of all of these wounds. This presentation will concentrate on the closure of wounds by suturing; so we first need to consider which wounds are suitable for surgical closure, at what point should we close them, and then how we will close them.

Wound Classification and Assessment

Other than by referring to the aetiology of the wound, it is common to describe wounds by their level of contamination with bacteria and foreign material. Wounds are classified as: Clean; Clean-Contaminated; contaminated; or Dirty/Infected.

CLEAN WOUNDS; These are made under sterile conditions, an operative wound in which no inflammation is encountered, and there is no entry of the gastrointestinal, respiratory, or genitourinary systems. There must be no breaks in sterile technique. These wounds are closed primarily and if necessary drained with closed drainage. Examples: Splenectomy, ovariohysterectomy.

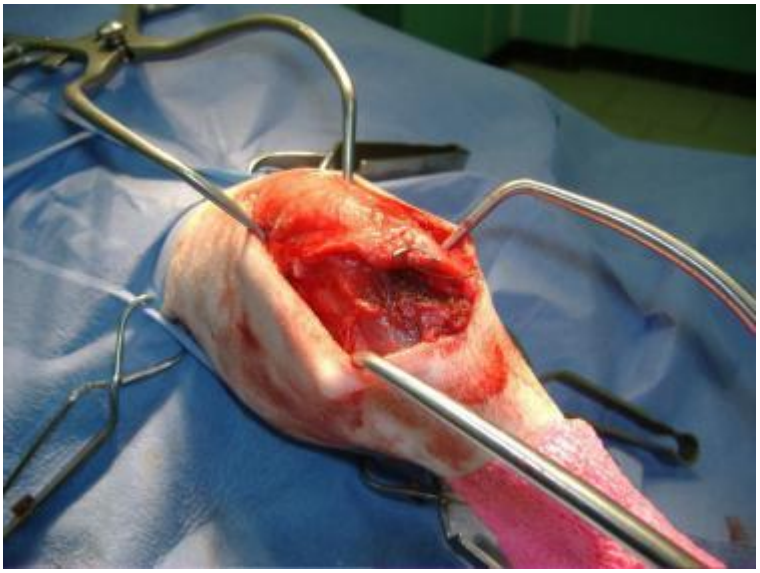

Figure 1.Stifle arthrotomy, elective 'Clean' wound

CLEAN-CONTAMINATED WOUNDS; These are operative wounds made under sterile conditions, during which the gastrointestinal, respiratory or genitourinary system is entered. There is minimal contamination which is easily removed or reduced to insignificant levels. Traumatic wounds are NEVER clean-contaminated, but may be converted to a clean-contaminated state through debridement and lavage. Examples: Bladder surgery, enterotomy, gastrotomy, elective caesarean section.

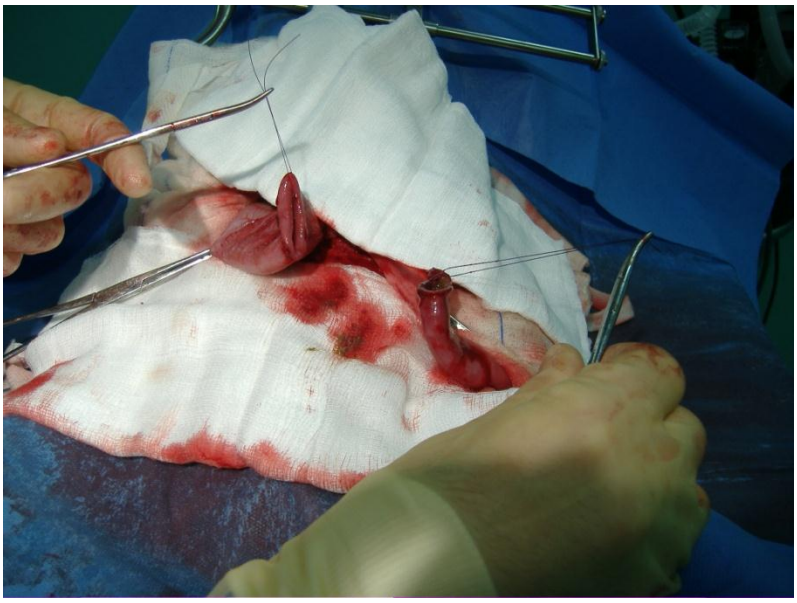

Figure 2. Enterectomy, 'Clean-Contaminated' wound.

CONTAMINATED WOUNDS; Open, fresh, accidental wounds or surgical wounds with major break in aseptic technique- e.g. spillage of gastrointestinal contents. There is heavy contamination and often foreign material in the wound. Examples: Rectal surgery, acutely presented traumatic wounds.

Figure 3. Traumatic laceration. 'Contaminated' wound

DIRTY or INFECTED WOUNDS; These are old traumatic wounds with active infection, or involving a punctured viscus. Examples: Septic peritonitis, intra-peritoneal abscess.

Figure 4. Dog bites , 7 days since injury. 'Dirty/Infected' wound

By studying these definitions, it is obvious that ALL traumatic wounds are either contaminated or dirty. As ONLY clean or clean-contaminated wounds should be closed, then all traumatic wounds will need lavage, debridement and management prior to considering closure.

The other important consideration of any wound is the degree of wound ischaemia. A wound with devitalised tissue present will require smaller numbers of bacteria to establish a wound infection. Consider also vascular damage to deeper structures. Crushing injuries and puncture wounds (or a

combination of the two, i.e. bite wounds) can cause vascular damage beyond the grossly visible margins of a wound.

Wound Infection Rates

Postoperative wound infections have been documented in 5 % of ALL small animal surgeries. In 'clean' procedures a rate of 2.5% has been recorded, rising to 10% in 'dirty' wounds where the bacteria causing the postoperative infection are already established.

Normally host neutrophils and the macrophages will phagocytose bacteria and prevent infection. But, if bacteria numbers exceed a critical level, then infection will occur- this critical level is different for EACH INDIVIDUAL WOUND, and depends on;

1) Host Factors- Infection id more likely if the animal is immunocompromised from pre-existing disease (diabetes, Cushings, neoplasia) or medication.

2) Local Factors- Wound conditions that prevent the action of phagocytosis promote infections; haematomas and seromas, braided suture material and drains, all provide environments where bacteria can thrive 'out of reach'

3) Bacterial Factors-Some bacteria with endotoxins, such as E Coli, cause cell damage and prevent phagocytosis.

Wound Closure Options

Skin wounds can be dealt with via:

1) Primary Closure,

2) Delayed Primary Closure

3) Secondary Closure

Or **4) Second Intention Healing**

Primary Closure- only performed on clean wounds, or clean-contaminated wounds with little ischaemic damage to tissues. Immediate closure is performed, without tension. In practice this means the closure of clean surgical incisions made under aseptic conditions, or the closure of clean-contaminated lacerations following lavage and debridement. There is only a small risk of infection and normal healing is expected.

Delayed Primary Closure- carried out 3-5 days after the wound was inflicted. This allows a period of open wound management to eliminate contamination and devitalised tissue with lavage and repeated debridement. Suitable wounds are clean-contaminated or contaminated, or wounds with areas of questionable tissue viability. The closure is carried out before any granulation tissue forms.

Secondary Closure- carried out on contaminated or dirty wounds, 5-7 days after the wound is inflicted. This extended time frame allows management of an infected wound or the removal of foreign material and devitalised tissue. The wound is managed with dressings, and then closed after the appearance of granulation tissue.

Second Intention Healing-wounds that are unsuitable for closure, or have extensive contamination and devitalisation can be allowed to heal by granulation, wound contraction and epithelialisation, without surgery. Disadvantages can include prolonged healing times, poor cosmetic results, and restriction of joint movement due to wound contraction.

Timing of Wound Closure

As can be seen from the above, when considering when to close a wound, the most important consideration is the presence of contamination and the presence of any necrotic tissue. Once a wound has been converted via appropriate management to a clean-contaminated state it can be closed or reconstructed as soon as possible. If dealing with a relatively small contaminated wound in an area with available adjacent skin (such as on the trunk of a dog), a technique of 'en-bloc' debridement can be performed and the entire area excised and the resulting deficit closed primarily; this technique saves time compared to the process of on-going lavage and debridement followed by secondary closure.

In some cases we may not elect to close a wound at the earliest opportunity. It may be cheaper to the client to allow a wound to heal by second intention, but do not under estimate the costs involved in ongoing open wound management, including dressing changes and repeated sedations.

In certain situations though, early reconstruction is strongly advised. These include wounds where: Vital structures are exposed, areas near joints where contraction will affect joint function, near eyelids or lips.

Surgical Principles and Techniques for Wound Closure

How we close the wound is as important as when we close the wound.

While handling the tissues and placing sutures we need to use aseptic technique, reduce contamination and minimise tissue injury; this will aim to preserve blood supply and therefore tissue oxygenation leading to enhanced healing.

Hallstead's principles of surgical technique still provide essential guidelines today:

Strict aseptic technique
Gentle tissue handling
Sharp anatomic dissection of tissues
Preservation of blood supply
Meticulous haemostasis
Careful approximation of tissues
Management of dead space
Little or no tension across suture lines

Basically once we have managed a wound to the point where we are able to close it, we do not then want to re-introduce bacterial contamination and devitalised tissue during our closure!

One of the most common faults is to place skin sutures too tightly, this causes pain, self-trauma, tissue ischaemia and likely wound breakdown. Skin sutures should gently appose the skin edges without crushing, if you are relying on the strength and tension of the suture to close the skin then breakdown is inevitable. Allowance should be made for swelling post-operatively. Closure of skin is

improved with the placing of intradermal sutures to hold the edges in apposition prior to the placement of skin sutures. This stabilises the skin edges and means there is no need for any tension on the skin sutures, so reducing ‘cut out’ and wound breakdown.

Avoiding Wound Tension and Dead Space

Closing a wound without tension at the wound edges can be impossible in some situations, such as where skin masses have been resected, or in large traumatic wounds. In these cases other techniques may be required to allow either allow closure without tension, or to bring in ‘extra skin’ to be utilised in the reconstruction.

The simplest of these techniques make use of the elastic properties of our patient’s skin without resorting to additional flaps or grafts.

Undermining is effective at reducing tension; by a combination of sharp and blunt dissection at the wound edges, loose connective tissue attachments below the skin are broken down allowing more mobility.

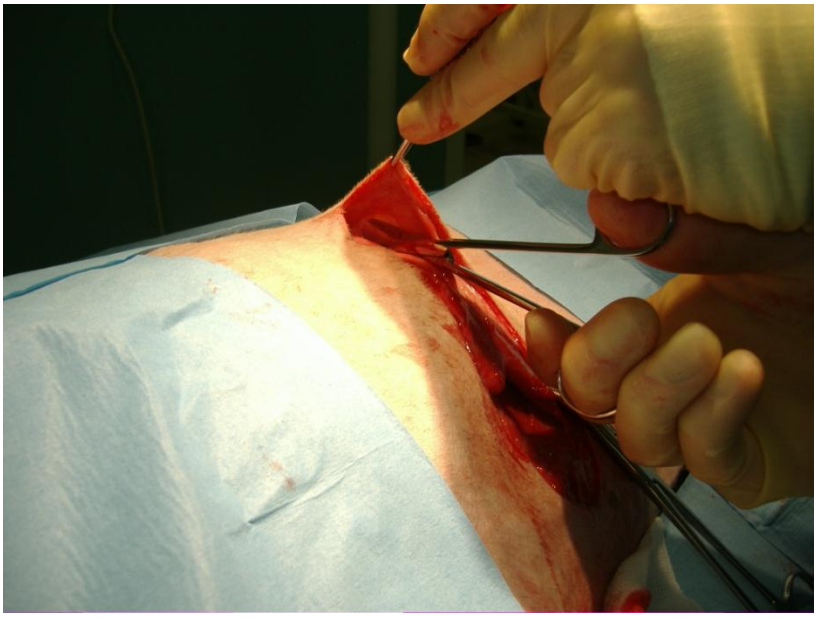

Figure 5. Undermining margins to achieve tension free closure

‘Walking sutures’ can then be used after undermining has been performed. A ‘bite’ is taken with the needle in the dermis of the skin, and then through the fascia of the wound bed relatively closer to the middle of the wound. When the suture is tightened, the overlying skin is advanced towards the wound centre. This has two purposes, to distribute tension away from the wound edges, and also to advance the undermined skin.

Where the above techniques are insufficient, then local skin flaps, axial pattern flaps and skin grafts are often used.

When reconstructing a wound, leaving dead space needs to be avoided. Dead space is likely to fill with seroma or haematoma, leading to discomfort, delayed healing and providing an ideal environment for bacteria to multiply. Dead space can be managed by the use of walking sutures to close down the area, but this leaves more foreign material in the wound. Bandaging the area to apply pressure and so eliminate dead space is preferred.

Where bandaging is not possible, then drains should be used to remove air and fluid from the wound and eliminate dead space. Passive open drains (e.g. Penrose) can be used, but in a ‘clean’ wound the use of a closed, active drain is preferred. In a closed drain the tube is more rigid to allow suction to be applied without collapsing, and is fenestrated. A suction source is required; this is normally attached to the animal. These systems are either commercially available- e.g. ‘grenade’ drains, or can be improvised from sterile tubing and syringes/vacutainers. The suction applied acts as an ‘atmospheric bandage’ to eliminate the dead space and hold the layers next to each other.

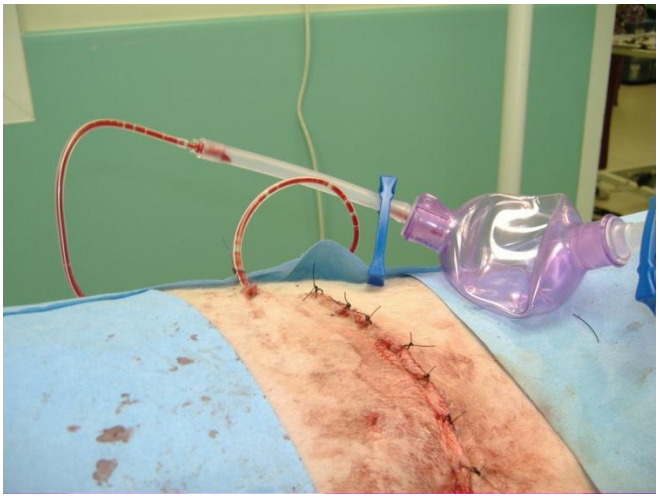

Figure 6. Commercial 'grenade' active closed drain.

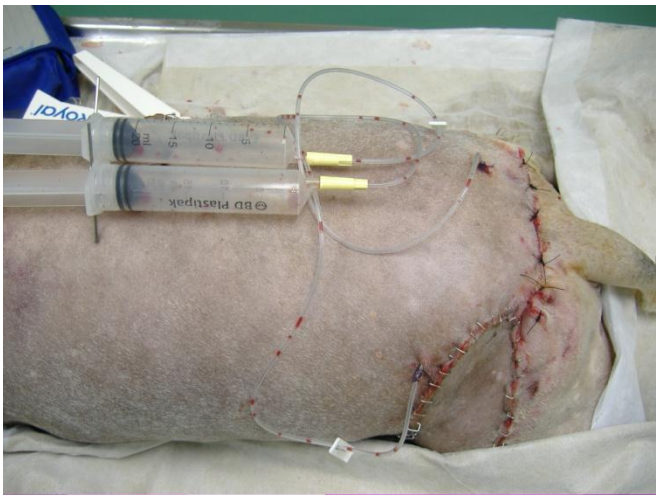

Figure 7. Improvised active, closed drain.

Suture Materials

Suture materials are categorised according to a variety of properties:

Absorbable vs Non-absorbable

Mono-filament vs Multi-filament

Natural vs Synthetic

An individual suture material may then be assessed in terms of its flexibility, handling characteristics, its strength, relative knot security, loss of strength over time, capillarity and time to complete absorption.

Absorbable vs Non-absorbable: Absorbable sutures generally undergo degradation with a rapid loss of tensile strength within 60 days. Non-absorbable sutures retain significant strength beyond 60 days.

Mono-filament vs Multifilament: Multifilament sutures are made by twisting or braiding multiple small strands into a larger suture. Mono-filaments are made from one strand made by extrusion.

Generally multi-filaments are easier to handle as they are more flexible, but their rough surfaces cause increased drag and can cut through the sutured tissue. The small spaces between the individual strands can harbour bacteria from contaminated wounds, and the presence of such suture material greatly increases the risk of wound infection in a contaminated wound.

Mono-filaments are less flexible and so more difficult to handle, but cause less tissue trauma and decreased bacterial adherence.

Natural vs Synthetic: Historically the first suture materials were of natural origin, (e.g. cotton and linen). Synthetic materials are produced from chemical polymers.

The use of natural suture materials is now rare, remaining types in use are catgut, silk and stainless steel. Catgut is broken down by phagocytosis and its rate of absorption is unpredictable. Silk tends to be used for its excellent handling characteristics, usually to ligate vessels.

Synthetic absorbable sutures are absorbed by hydrolysis, which induces little tissue reaction. As they are made from uniform material, the rate of absorbtion is predictable.

Selection of Appropriate Suture Material

The aim of any suture is to hold together the tissues that have been cut until they are healed. It is therefore important to select the suture appropriate for each tissue based on the expected rate of healing for that tissue, but also considering any harmful effects the suture may have on the healing process.

Considerations include;

SIZE-The size of the suture material should be the minimum size possible to adequately hold the tissue while healing. Larger suture size results in more tissue trauma, and a greater amount of foreign material so increasing the risk of infection.

STRENGTH OF TISSUE-The suture should be at least as strong as the tissue through which it passes. The strength of the tissue and its ability to hold sutures without tearing depends on its collagen content and the direction of the fibres

LOSS OF SUTURE STRENGTH AND GAIN OF WOUND STRENGTH-We need our suture material to appose the tissue until it has healed. Therefore the loss of strength of the suture material as it is absorbed must be matched by a gain in strength of the tissue as it heals. This is an important consideration in slowly healing tissues under constant strain such as tendons and ligaments.

CAPILLARITY-Fluid and bacteria can be carried into the structure of a multi-filament suture. Neutrophils and macrophages are larger and are unable to follow, leaving the bacteria safe from phagocytosis. For this reason the use of multi-filaments should be avoided in contaminated wounds, and where 'wicking' of fluid along the suture deeper into the wound can occur, such as with skin sutures, or intestinal sutures.

The ideal suture material should;

Be easy to handle
React minimally within the tissue
Hold securely when knotted
Create minimal drag through tissues
Maintain adequate tensile strength until healing is complete
Have a rapid resorption without reaction once tissue healed
Be easy to sterilise without changing property
Not favour bacterial growth
Be non allergenic.

In practice no such material exists, and a suture should be selected that best matches the properties required for the tissue and wound it will be used for.

SKIN- Synthetic monofilament suture material is recommended. Multi-filaments should be avoided due to capillarity and the risk of 'wicking' fluid and bacteria into the wound.

SUBCUTANEOUS TISSUE- Skin sutures are often removed 10-14 days post-operatively, but only 20% of the skins strength is returned by 21 days. In view of this we need to provide support beyond this period with the subdermal or subcutaneous layers. A synthetic absorbable material is recommended.

LINEA ALBA-Fascia is slow to heal, so prolonged support is required during healing. A synthetic absorbable suture that is slow to lose its tensile strength is normally used. Non-absorbable synthetic material can be used where delayed healing due to patient factors is expected.

HOLLOW VISCUS ORGANS- e.g. Bladder and intestines. A synthetic absorbable monofilament is advised. Multi-filaments may cause more trauma and tissue drag, and potentially harbour infection. Non-absorbable suture material can be used in the GIT where slow healing is anticipated- such as in the colon, or in the presence of peritonitis.

TENDONS AND LIGAMENTS- Slow healing is expected, and high tensile strength is required. Synthetic absorbable or non-absorbable suture material is used.

Needles

The use of ‘swaged on’ needles is always recommended. Swaged needles can have a diameter only slightly larger than that of the suture material, ensuring the minimum of trauma to the tissue.

Needle shape is selected depending on the depth and accessibility of the wound or organ to be sutured. Generally the deeper the wound, the more curved the needle. Straight needles may be used for skin, or in some cases tendon suturing. Curved needles are formed in an arc and described as their proportion of an entire circle- i.e. ¼, 3/8, ½, 5/8.

The cross section of the needle and its point have are an important consideration.

Round body needles have a sharp point, and penetrate the tissue by dilation of an initial puncture, these are least traumatic, but cannot be used on tougher material without rapidly blunting. Tapercut needles are round bodied, but at the tip are honed to have 2 or more cutting edges. Cutting needles are triangular in cross section and used on tougher tissue such as skin. Conventional cutting needles have the inside edge of the curve(towards the wound) as the cutting surface, reverse-cutting needles have the cutting edge on the outside of the curve, away from the wound edge, to prevent ‘cut-out’.

Instruments and Handling

The size and type of needle holder used to grasp and manipulate the needle is determined by the characteristics of the needle, the location of the wound, and personal preference. Large heavy needles in tough tissue require wider, heavier jawed needle holders. Suturing inside a thorax requires longer needle holders. Intricate ophthalmic work requires small delicate needle holders such as Castroviejo type. The most commonly used needle holders are Mayo-Hegar, and Olsen-Hegar (incorporating scissor blades).

Needle holders should grip perpendicular to the needle, near its centre to prevent damage to the needle swage or tip. Gripping the needle holders in a ‘thumb-ring finger’ grip allows for the most precision.

Tissue forceps are used to stabilize tissue or expose tissue layers during surgery. They are available with a variety of tips, tissue forceps with large teeth (e.g. ‘rat-toothed’ forceps) should not be used to handle easily traumatised tissue. Most commonly used are Brown-Adson (small serrations at the tips) or DeBakey (interlocking ridges).

Knot Tying

The knot is the weakest point of the suture, the knot is formed by at least two throws formed on top of each other and tightened. The number of throws required to tie a secure knot depends on the suture material and suture pattern. Mono-filaments require a greater number of throws, multi-filaments generally require less throws. The beginning and end of a continuous suture line will require more throws than a simple interrupted suture.

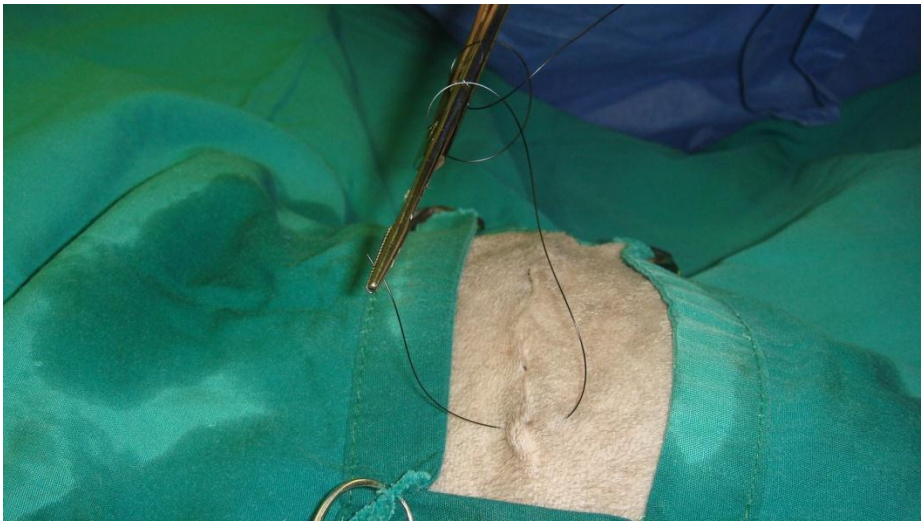

Figure 8. Double loop on needle holders to form first throw of 'surgeons knot'

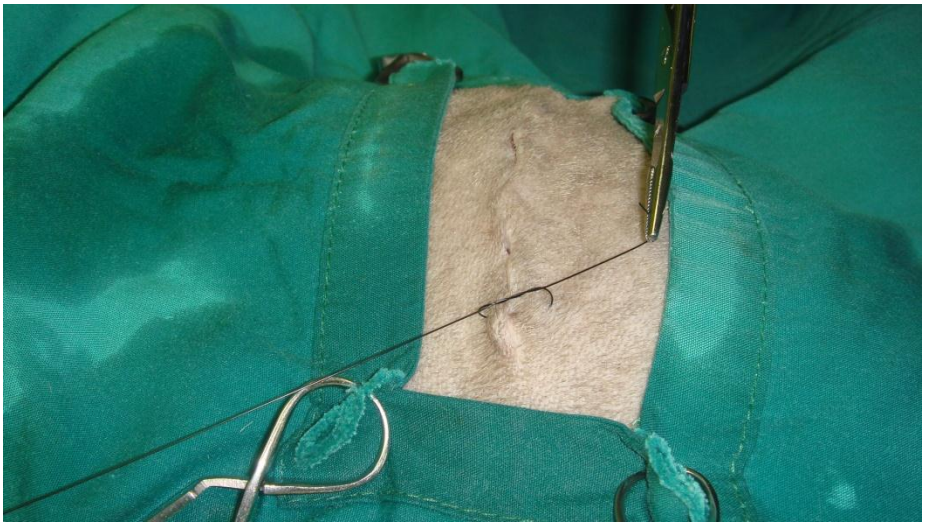

Figure 9. Hands crossed from previous position to tighten first throw.

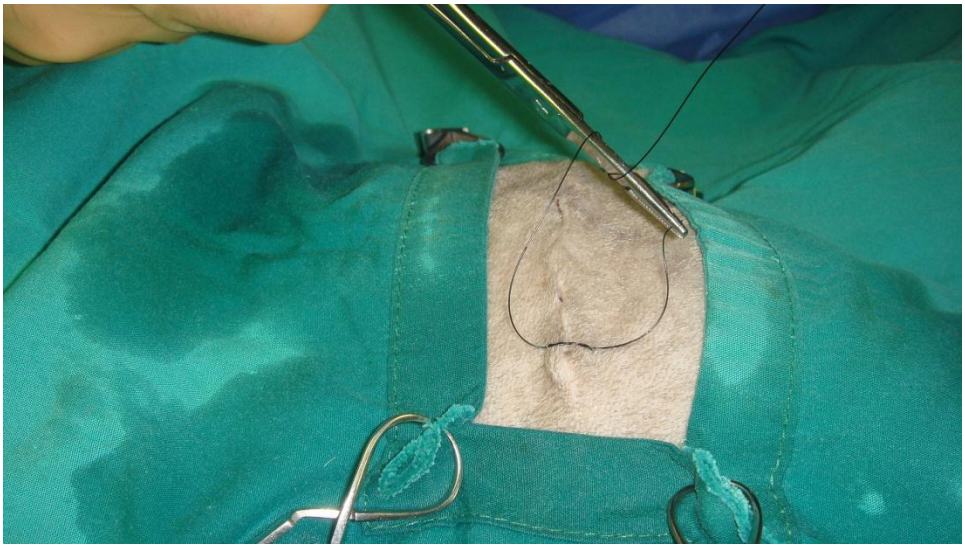

Figure 10. Single loop to form second throw of knot.

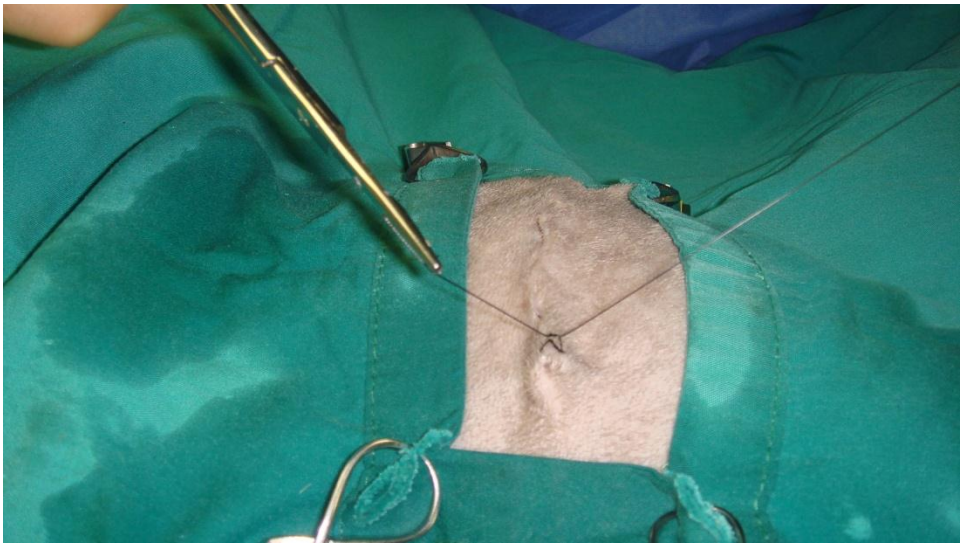

Figure 11. Second throw tightened.

Suture Patterns

Interrupted suture patterns vs continuous?

Advantages of simple interrupted patterns are greater security, and allowing the precise adjustment of tension at each point of suturing.

Disadvantages are that more suture material is used, this costs more and leaves more foreign material in the wound, they are also more time consuming (longer anaesthetic means greater wound infection risk).

SIMPLE INTERRUPTED

Quick and easy to apply, they are appositional unless excessive tension is applied; then they tend to invert the tissue. Used most commonly for skin sutures. Needle is passed from one side of the wound to the other, and a knot tied.

For skin closure the sutures are placed 3mm from the skin edge and about 5 mm apart. A common mistake is to over-tighten the suture leading to tissue necrosis, and cut-through. Leave cut ends long enough to assist with removal.

Figure 12. Simple interrupted skin suture.

SIMPLE CONTINUOUS

A series of simple sutures with a knot at either end. Each bite is perpendicular to the wound edges, with the suture material advancing obliquely across the wound to begin the next suture. To end the suture, the end is tied to the last loop. A greater number of throws is required on the knot at the end and the beginning of a continuous suture.

FORD INTERLOCKING

This is similar to a simple continuous suture, but with a modification so that after each pass of the needle the suture is partly locked. This pattern can be placed quickly, and may give better tissue apposition than a simple continuous, but uses a lot of suture material, and also if used in the linea alba, does not give as good a protection against herniation between sutures.

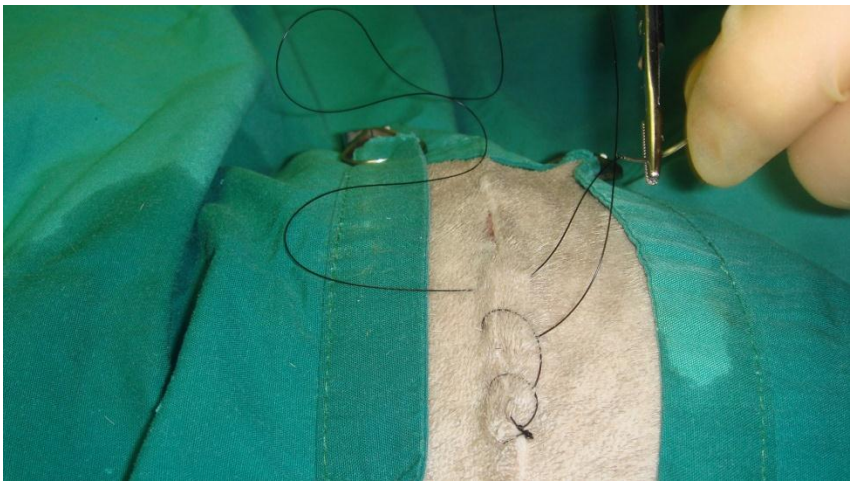

Figure 13. Ford Interlocking Suture, continuous partly locked at each bite.

CRUCIATE

An interrupted suture that is basically 2 linked simple interrupted sutures. Quicker to place than simple interrupted, but the tissue apposition is not as accurate.

Figure 14. Cruciate suture, needle has crossed wound twice, about to be tied.

HORIZONTAL MATTRESS

Interrupted sutures placed in areas of tension, quick and easy to place, but cause tissue eversion. The needle is passed across the wound as for a simple interrupted, then advanced 6 to 8mm and passed back across the wound in the other direction and tied.

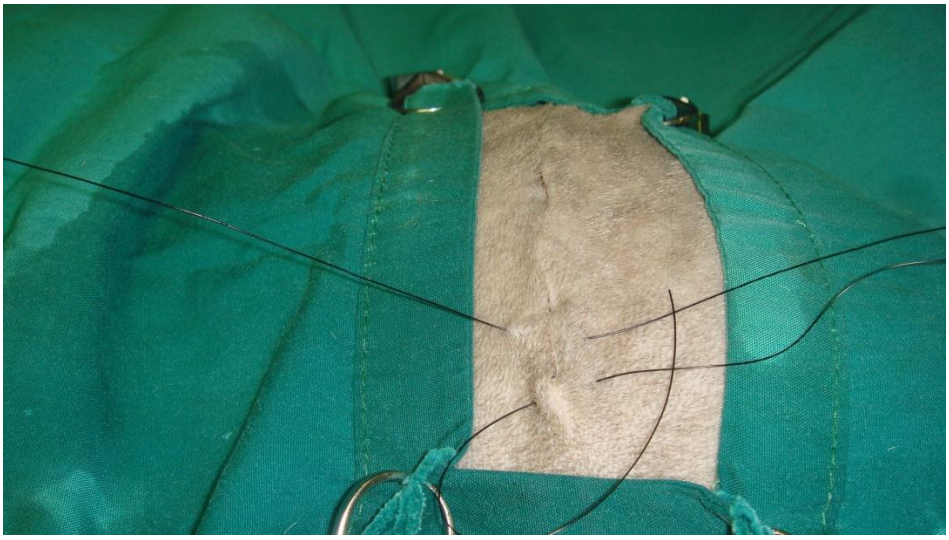

Figure 15. Horizontal matress. needle crosses wound, and is then reversed and crosses the opposite way.

SUB-CUTANEOUS and SUB-CUTICULAR

Sub-cutaneous sutures are placed to eliminate dead space and ease tension on skin sutures; they are usually placed in a simple continuous fashion. The starting knot is buried below the dermis, and then vertical bites are taken each side of the wound and the suture advanced in between.

Sub-cuticular sutures are used to appose skin edges, and may be used with skin sutures, skin staples, tissue glue, or on their own for skin closure. Horizontal bites of the sub-cuticular tissue are taken, with the suture advancing within the tissue.

Stapling

Skin staples are commonly used for skin closure, and the same principles as skin suturing apply- i.e. they should not be under any tension, and are best used where a sub-cuticular suture layer has already been applied to hold the skin in apposition. Make sure both skin edges have been penetrated, and the points of the staple meet to prevent rotation.

Summary

WHAT wounds to suture- we are only going to suture Clean or Clean-Contaminated wounds.

WHEN to suture the wound- reconstruct wound as soon as possible once has been converted to a clean/clean-contaminated state and all ischaemic tissue removed

HOW to suture the wound- reconstruct without tension on skin, using appropriate suture material, of appropriate size, and using Hallstead's surgical principals so as not to cause further trauma.