Surgical Asepsis and Soft tissue Surgery technique
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An animal's surgical risk is influenced by the significance of its presenting disease and other preexisting abnormalities. Preoperative assessment and stabilisation of the patient allow the surgeon to anticipate complications and to reduce their occurrence.

Likewise, preoperative preparation of the patient and operating team helps minimise potential infection. Antiseptics reduce bacteria on the patients and surgeons skin to low levels throughout surgery. Sterile barriers are placed between contaminated surfaces and the incision to reduce bacterial contamination of a surgical wound.

Surgical risk weighs the relative benefits of surgery against its potential for harm. Surgical risk should consider the risk of anaesthesia and surgery, prognosis, potential complications and animals quality of life after the surgery.

General considerations for surgical preparation

Excessively soiled patients are bathed before surgery to reduce contamination of the operating room and surgical site. Food is withheld for 12 hours before surgery to minimise the potential for vomiting and aspiration during anaesthesia. Animals younger than 4 months may have limited glycogen reserves so fasting should not exceed 4 hours. Free access to water is maintained until the time of premedication and animals are walked prior to surgery to encourage voiding.

Bacteria contaminating surgical wounds generally originate from the patients endogenous flora, operating room personnel, and environment.

To prevent wound contamination becoming a serious clinical problem, strict rules of aseptic technique must be followed. Breaking these rules may result in increased risk of bacterial infection.

Surgical team members remain within the sterile area
Talking is kept to a minimum
Movement within the operating room is minimal
Non scrubbed staff do not reach over sterile field
Equipment used during surgery must be sterile
If sterility of instrument ? then consider contaminated
Drapes should be moisture proof
Sterile instruments within damaged wrapper are considered contaminated
Dont fold hands into the axillary region

A variety of physical layouts are suitable for modern operating rooms. The goal of design is patient safety and work efficiency. Ideally, the surgery area should be
divided into contaminated and clean working zones. The clean zone should include the operating room, scrub sink area and sterile supply room. Contaminated zones include anaesthesia preparation rooms, offices, corridors etc. Traffic in the clean zones should be restricted to clean staff. Correct surgical attire must be worn in clean zones. Ideally, surgical attire should be covered when staff move into contaminated zones. Doors between contaminated and clean zones should be kept shut at all times. Patients should be clipped and prepared for surgery in the contaminated zone before being moved into the clean zone.

Surgery puts animals at risk of nosocomial infections (hospital acquired) unless strict environmental, equipment care and maintenance standards are established and followed. Most bacterial contamination takes place during surgery, therefore, proper preparation of the surgical environment is crucial to reduce the likelihood of infection.

The operating room is considered a clean area. Appropriate attire must be worn by all personnel entering or leaving the room. Cleaning refers to removing blood, serum, urine, purulent exudate and disinfection refers to treatment of surfaces, material and equipment with disinfectants to reduce bacterial numbers.

After each surgical procedure, areas contaminated by organic debris (floors, doors, counters, equipment, operating table etc) should be cleaned/disinfected.
At the close of each day, operating tables, counters, lights, equipment, floors, windows, cabinets, and doors should be cleaned/disinfected in preparation for the following days activities. Linen and waste bags should be collected, linen laundered, and waste disposed of properly. Kick buckets should be disinfected and plastic bags replaced. Surgical lights, monitoring equipment, and anaesthetic equipment are cleaned/disinfected following manufacturers specific guidelines. Wheels and coasters of all movable equipment are cleaned/disinfected. The operating room should be restocked with instruments, suture material. Gauze sponges, needles, and syringes and the floor should be vacuumed and damp mopped.

Scrub sink areas need special attention during the day because water, which is a vehicle for bacterial contamination, is frequently splashed on floors and walls, and blood and other organic debris can be tracked from the scrub sink area to the surgical suite. This area should be cleaned as needed throughout the day and disinfected at the end of the day.

**Anaesthesia and surgical preparation rooms**

Sinks, buckets, tabletops, should be kept clean of organic debris and disinfected as needed throughout the day. Hair removed during patient preparation should be vacuumed from surgical tables and floors. Blood, urine, faeces, tissue, serum, and purulent material should be contained and discarded. Needles and sharps should be disposed of in appropriate containers. Plumbing fixtures, floors, cabinets, anaesthesia equipment, utility rooms, furniture, and other equipment should be cleaned and disinfected daily. At the end of the day, sinks should be disinfected and a cup of disinfectant solution poured down the drain. Inner garbage containers should be cleaned and disinfected. Clippers should be wiped clean and disinfected. Floors vacuumed and damp mopped and supplies restocked.

**Weekly and Monthly Cleaning routines**

Surgical suites should be emptied of moveable equipment and thoroughly cleaned once a week. Shelves of supply cabinets, walls, windows, windosills, ceilings, light fixtures, surgical tables, utility and supply carts and castors, equipment storage area cleaned and disinfected. At least once a week operating room floors and associated vents should be vacuumed. Once a month, walls, floors and ceilings should be mopped and wheels and other moveable parts of equipment should be lubricated.

**Remove hair**

Pre-induction: Advantages – can reduce anaesthetic time, improves asepsis, improves OR efficiency. Disadvantages – requires two or more people, patient may be uncooperative, clipping more than 12 hours prior to surgery increases skin bacteria.

Post-induction: advantages – desirable with un-cooperative patients, required for painful and inaccessible site, takes less time. Disadvantages – increases anaesthetic time.
Shaving versus clipping: shaving with a razor/surgical blade should be avoided because this causes numerous miniature lacerations that encourage colonisation of bacteria. Electric clippers provide an efficient and safe way to remove hair.

**Preparation of the operative site**

Staphylococcus aureus and Streptococcus spp are the most common source of surgical wound contaminants. The skin and hair of animals are a reservoir for bacteria. Normal or resident organisms live in the skins superficial cornified layers and outer hair follicles. Resident canine flora include Staph Epidermidis, Corynebacterium spp., and pityrosporpon spp. while Staph Aureus and Intermedius, E Coli, Streptococcus spp, Enterobacter spp. and Clostridium spp are transient pathogens. Although it is impossible to sterilise skin without impairing its natural protective function and interfering with wound healing, preoperative preparation reduces infection.

Correctly identify your patient before beginning any procedure. Confirm the procedure to be carried out. Some texts suggest bathing the animal 24hrs before surgery although this can be questioned. All forms of hair removal cause some skin trauma and inflammation. Any injury to the skin may result in bacterial colonization. Surgical wound infection rates increase as the time between hair removal and surgery increases. When hair is removed from the site before anaesthetic induction, the surgical site is three times more likely to become infected than if the hair is removed after anaesthetic induction Brown DC et al JAVMA 210; 1302, 1997

Razors leave minimal stubble ut cause multiple lacerations and skin erosions that are rapidly colonized by bacteria. They have been associated with up to a 10 fold increase in surgical wound infections, so they are not recommended Cruse and Foord Arch Surg 107;206, 1973Clipping is the recommended method of hair removal in animals. It causes less skin trauma and is associated with fewer surgical wound infections than any other techniques.

Clip hair liberally around the proposed surgical site. Check with the surgeon before doing this. Occasionally, extension of the primary incision may be needed. A guideline is to clip 15-20cm on each side of the proposed incision line. For orthopaedic procedures on long bones, the full circumference of the limb is clipped to the dorsal midline. The foot may or may not need to be clipped. Animal digits have a high resident bacterial population, therefore if access to the paw is unnecessary, it should be covered with an impermeable material eg latex glove and wrapped in a co-hesive bandage. Paws are difficult to clip without causing significant skin reauma. In addition, the nail beds, undersurface of the nails, and the pads are difficult to clean effectively. Use an electric clippers with a No. 40 blade. Thick coated dogs with a heavy coat may require a No. 10 blade initially. The higher the number on the blade the shorted the remaining hair. Clippers should be held with a pencil grip and start by going in the direction of the hairs. Keep the clipper blade parallel to the skin. Subsequent clipping is done against the pattern of hair growth to get an even closer clip. Blunt blades and broken teeth damage the skin and should never be used. Blunt blades can be sent for re-sharpening as required. Thin skinned animals eg cats and poodles are very
sensitive and susceptible to clipper blade burns from over-heated blades. To prevent blade burns, lubricants and coolant sprays should be applied to the blade throughout the clipping procedure. Loose hair is removed with a vacuum.

For limbs, if the paw is not to be included in the surgical field, cover it with a latex glove, tape and then bandage material. The foot is then ‘draped-out’ of the sterile field. To facilitate limb management during surgery, a ‘hanging-leg’ preparation may be used. This means that the entire 360 degrees of the limb is clipped and aseptically prepared for surgery. The limb is suspended from an IV pole during surgical prep to allow access to all sides of the limb.

Care should be taken to prevent contamination from loose hairs and debris. Wounds should be covered with saline soaked lint free swabs or instilled with a sterile water soluble gel eg KY jelly or intrasite gel.

We perform surgical preparation in the treatment room and then transport the animal into the operating room. In male dogs undergoing abdominal procedures, the prepuce should be flushed with an antiseptic solution.

**Scrub techniques for Skin**

**Antiseptics**
Antiseptics prevent growth or action of microorganisms on living tissue by either inhibiting their activity or killing them.

**Iodophors**
Iodine is an effective antiseptic but its use is limited by the odour, staining, tissue irritation and corrosiveness that accompany its application. To reduce the undesirable effects of iodine, it has been combined with carriers termed iodophors. These produces allow a slow continuous release of free iodine. Iodophors have reduced staining and local tissue toxicity, with preserved broad spectrum antimicrobial activity. A 10% povidone-iodine solution contains 1% available iodine. Dilution of the 10% solution releases more free iodine, making it more bactericidal than the concentrated solution. Iodophors must be in contact with the skin for at least 2 minutes to release enough free iodine to kill bacteria. They have reduced activity in the presence of organic materials like blood, fat, and necrotic debris. Skin is cleaned before iodophors are used to reduce organic debris. Iodophors are effective in reducing the number of bacteria on canine skin for 1 hour after application. They have persistent activity for 4-6 hours.

**Chlorhexidine gluconate**
This is a rapidly acting agent with a broad spectrum of activity. Unlike the iodophors, chlorhexidine remains effective in the presence of alcohol, as well as blood, pus, and other organic material. Contact time of at least 2 minutes are recommended. Chlorhexidine has an excellent persistent and residual activity. Continued daily use results in extended residual effects that lower bacterial skin counts over time. Chlorhexidine causes minimum skin irritation. It is ototoxic.
Alcohols
Alcohols have a broad spectrum of bactericidal activity. The isopropyl form is more bactericidal. Alcohols have a rapid initial kill with short contact time. They are drying agents with mild defatting effects. Alcohols increase the effectiveness of chlorhexidine and iodophors. They are toxic to open wounds. Prolonged exposure may result in drying and irritation of skin.

Of the antiseptics discussed, alcohols have the highest and most rapid kill rate. Applications of 30-60 seconds kill 98% of bacteria. Chlorhexidine has the next highest immediate action at 96% after 30 seconds and 98% after 3 minutes, followed by Povidone-iodine at 77% after 3 minutes. Chlorhexidine is superior to povidone-iodine for patient and surgical preparation because of a wider range of antimicrobial activity, longer persistent and residual action, minimal loss of activity in the presence of organic material and decreased skin reactions and toxicity. Clinically, there is not a lot of difference between the two products in surgery wound infection rates.

The function of skin preparation is to physically remove dirt, chemically reduce the microbial population and to provide residual anti-microbial activity. Skin harbours transient and resident bacteria. Scrubbing reduces bacterial numbers by the action of the surgical scrub (chemical) and scrub brush (mechanical). Remember, skin cannot be sterilised only disinfected. Approximately 20% of residual bacteria reside in the deeper layers of the skin, where they are inaccessible to antiseptic solutions.

Scrub solution is applied to moistened lint free swabs or sponge and the use of a gloved hand may be more effective in reducing bacterial numbers. Scrub brushes cause excessive trauma. Overzealous scrubbing is to be avoided because it brings bacteria within hair follicles to the skin surface and causes abrasions that become colonized. Excessive water volumes during scrubbing will result in wetting the animal, increased heat loss and moisture contamination. The skin is scrubbed with scrub solutions to remove debris and reduce bacterial populations. The area is lathered well until all dirt and oils are removed. This is a generous scrub that often encompasses the hair surrounding the operation site to remove unattached hair. Gentle scrubbing is started at the incisional site, usually near the centre of the clipped area for 1-2 minutes. A circular scrubbing motion is used, moving from the centre to the periphery in enlarging circles. Sponges should be discarded after reaching the periphery and the process is repeated until the area is free from dirt. A contaminated swab should never be returned from the periphery to the centre because bacteria could be transferred onto the incisional site. This mechanical process may need to be repeated 3-5 times. The Comparison of skin preparations (povidone-iodine, 4% chlorhexidine gluconate with saline, 4% chlorhexidine gluconate with 70% isopropyl alcohol) showed no significant differences in percentages of bacterial reduction for surgical times up to 8 hours in dogs. However, significantly more tissue reactions occurred with povidone-iodine than with chlorhexidine. 4% chlorhexidine with 70% isopropyl alcohol was inferior because it resulted in fewer negative cultures after surgery.
The soapy film on the animals skin should then be wiped away with moistened lint-free swabs, again working from the incision site outwards. Alcohol should be applied when the skin is clean. A final preparation of aqueous solution (iodine/chlorhexidine) antiseptic of chlorhexidine tincture should be applied. Contact time is critical for chemical disinfectant process and is 3 minutes for chlorhexidine and 5 minutes for Povidone Iodine.

After careful and thorough aseptic preparation of the skin the dog is transferred to a trolley, without contamination. The animal is then moved into the operating room and carefully placed on the table. If monopolar diathermy is to be used the ground plate should be placed before the animal is positioned on the table. Avoid contaminating the surgically prepared area during the transfer. The animal is secured with tapes, sandbags, troughs, or vacuum-activated positioning devices. If a hanging-leg preparation is being done, the limb should be carefully suspended with tape from an IV pole or ceiling suspended hook.

After the scrub is completed, and antiseptic is applied. Commonly used preparations are 70% ethyl alcohol and tinctures of chlorhexidine and iodine.

**Draping**

The purpose of sterile drapes is to create and maintain a sterile field around the operative site. Bacteria within hair follicles are inaccessible to antiseptics used during preparation and migrate to the skins surface during surgery. The purpose of skin draping is to prevent these bacteria from contaminating the surgical wound. Skin draping also minimises contamination of the surgeons gloves if frequent touching of the skin is required during surgery. To be effective, a skin drape must provide an impermeable barrier under both wet and dry conditions. Furthermore, it must remain securely fastened to the skin during manipulation. Unsterile areas are covered by using either reusable or disposable drapes. We tend to use a combination of both reusable and disposable drapes for all major procedures. Drapes may be fenestrated with appropriate sized gaps or plain. Fenestrated drapes are routinely used for neutering techniques. Drapes should be large enough to cover the animal and hang over the table edge, ensuring a sterile area. Draping is performed by the scrubbed/gloved surgical member of the team.

Plain drapes: Plain drapes are placed around the surgery field and kept in place with towel clips. These are placed one at a time at the periphery of the prepared area. I normally start by placing the first drape between me and the animal to minimise contamination of my surgical gown with the animals unsterile body. The following drapes are placed at right-angles to each other and secured with Bachhaus towel clips. Fenestrated drapes may be used for small operative procedures. Drapes should be water-proof to prevent ‘strike-through’ of bacteria and to reduce wetting of the animal during the surgery procedure. Once drapes are placed and anchored by Bach-haus towel clips they should not be moved towards the incision. The tips of the towel clip are considered nonsterile once placed through skin and should be handled appropriately. It can be very useful to cover any exposed unclean regions of the animal with additional sterile drapes to
provide a continuous sterile field. If abdominal surgery is being done on a male dog, the prepuce should be clamped to one side with a sterile towel clip.

To drape a limb, drapes should be placed as described above to isolate the limb. The unsterile end of the limb is temporarily held by a nonsterile member of the surgical team while the sterile drapes are applied. A sterile drape or sterile vetwrap is used to bandage the foot, thereby allowing the sterile surgical team to handle the foot.

Instruments are then opened on the instrument table. It is important to use waterproof drapes on the instrument table and instruments should be suitably cooled before placing on the table.

**Preparation of the surgical team**
The surgery team are a major source of microbial contamination during surgery. Careful preparation of the surgery team reduced the bacterial numbers in the operating room. It will not eliminate bacteria.

There is a correlation between the number of people, their movements and the number of airborne bacteria in a surgery room (Fuller JR 1994) If possible, restrict the number of people in the operating room. In addition, locate the surgery theatre away from the main people traffic flow area.

**Scrub suits**
Strict guidelines regarding surgery attire. All surgery staff should be suitably dressed, whether a surgery is in progress or not. Scrub suits are worn in the surgery area to limit the amount of dirt, debris and bacteria that surgical staff carry into the operating room. Suits consist of top and pants. Tops should be short-sleeved to facilitate surgical scrub procedure and are worn tucked into the pants. Surgery scrubs are usually made of cotton mix material. They do not need to be sterile but clean scrubs should be worn. Routine laundering does not kill bacteria but periodic sterilisation decreases the numbers of pathogenic bacteria. Change surgery scrubs when wet or soiled to prevent transfer of microorganisms to the surgical environment. If surgery scrubs must be worn outside the surgery room, a lab coat or disposable surgery gown should be worn to cover scrubs. Scrub suits should not be worn to examine patients or change bandages. Hair hats, masks, shoe covers, gowns and gloves should be worn. Disposable caps are preferable to reusable versions from an asepsis perspective. Hair is a significant carrier of bacteria and complete coverage is necessary to reduce the shedding of hair and bacteria into the environment and surgical wound. The length of hair or the amount of facial hair does not appear to affect the type or number of resident bacteria. Even when surgery is not in progress, caps and masks should be worn in the surgery suite. Masks must be fitted over the mouth and nose and may be secured behind the top of the head and the neck region. Their function is to protect the surgical wound from saliva droplets and microorganisms by redirecting the air flow out the sides of the mask away from the surgery site. Masks filter and contain droplets of microorganisms expelled from the mouth and nasopharynx during talking. Their effectiveness reduces quickly over time, particularly when talking or sneezing. A variety of mask
designs are available. The most popular are soft synthetic fiber masks consisting of a fine glass fiber mesh sandwiched between two layers of nonwoven cellulose fabric. A thin metal strip is incorporated into the top of the mask to improve fit and security along the bridge of the nose. Avoid wearing the face mask around the neck when between procedures. Some masks are better filters than others. Efficiency improves with softness, pleating and size. Despite the demonstrated efficiency of masks in filtering particles, they have not been shown to decrease the air contamination in the operating room or the number of bacteria in the surgical wound. They are still recommended by all surgical staff during an operation.

Dedicated shoe wear is advisable and usually takes the form of antistatic clogs with rubber soles or similar. It is essential that the footwear is breathable and comfortable. Shoe covers are available to exclude dirt and bacteria on street shoes, but should only be used as a temporary measure because they wear through very quickly. Surgical gowns are available in fabric or synthetic disposable varieties. The choice may depend on many factors such as cost, effectiveness, comfort and personal preference.

Reusable fabric gowns are usually made of woven material (cotton). Woven fabrics are made by interlacing fibers that cross at right angles. The number of threads per square inch measures the tightness of the weave. The higher the number, the tighter the weave and the more effective the barrier achieved. Frequently used reusable gown are made of loosely woven 140 muslin fabric. This fabric is not ideal because it is instantly permeable to bacteria when wet, a process called ‘strick-through’. Dry penetration of bacteria occurs by one of three mechanisms; direct migration through the weave, airborne penetration, and rubbing through. The 14- cotton muslin is an ineffective barrier even when dry because its pore size is so large. Reusable gowns made from 270 pima cotton have twisted fibres that are woven into 270 threads per square inch. This is a tight weave but still allows bacterial penetration when wet. 270 Pima cotton can be treated to produce a water-repellant finish. This product is more expensive but provides a better bacterial barrier, but is not a uniform effective barrier. Woven drapes and gowns also produce lint that increases the particle counts in the operating room air and can cause foreign body reactions, especially in the abdomen. Torn gowns and drapes should be discarded because they no longer provide an effective barrier. Another reusable option is the polyester/cotton cloth which is available is a tightly woven fabric that resists bacterial penetration. Fabric gowns must be laundered after each use, folded and sterilised. Continuous laundering of any woven gown results in widening the fabric pores, increasing the risk of bacterial penetration.

Non woven disposable materials. Disposable gowns are made from fibres rather than yarn and water-repellant. They are typically made from regenerated cellulose, wood pulp, polyesters, synthetic polymer fibres, or combinations of these materials. They are formed into sheets and joined together. The random pattern of fibres are meant to prevent fluid and bacterial penetration. The barrier properties of the various nonwoven materials are highly variable. Only those reinforced with plastic or polyethylene film totally prevent moist and dry
penetration at pressure points. Totally impermeable materials tend to be uncomfortably hot to wear. They tend to be less conforming and breathable due to the material used. They come pre-packed and pre-sterilised. The number of microorganisms isolated from the surgical environment is lower when disposable gowns are used.

Both 270 pima cotton treated with a water-repellent process and nonwoven material proved to effective barriers and are considered acceptable for sterile surgery. The gowns with the best barrier properties have the front reinforced with a second layer of material or plastic. Neither system is perfect and the length of time the gowns or drapes are used is important for determining the level of bacterial contamination.

Disposable draping materials result in lower particle counts in the operating room air. They are reported to decrease the number of bacteria isolated from the surgical wound by up to 90% over cloth draping systems P Dineen Clin Orthop 96;210, 1973. In several studies, disposable drapes decreased surgical wound infection rates up to 2.5 times.

The skin is a natural barrier breached during surgery. Most surgical infections are caused by the patients flora. Preparation of the surgical site and operating team minimises the number of bacteria introduced into the surgical wound. Infection rates of 2.5% for clean surgeries, 4.5% for clean-contaminated surgeries, 5.8% for contaminated surgeries and 18.1% for dirty surgeries for an overall infection rate of 5.1% PB Vasseur Vet Surgery 17;60, 1988

Airborne contamination plays a minor role in surgery wound infection rates unless the procedure is prolonged or a prosthetic device like a total hip is implanted. The air in a clean, unoccupied operating room with a conventional airflow system contains about 250,000 particles per cubic foot. This increases with the number of people and level of activity in the room, the amount of uncovered skin areas, and the amount of talking.

**Surgical Scrub**

The purpose of the surgical scrub is to clean the hands and forearms and reduce bacterial numbers that come in contact with the wound during surgery. The scrub procedure should not be time consuming or irritate the skin. All members of the sterile surgical team must perform a hand and arm scrub before entering the surgical theatre. The objectives of a surgical scrub include mechanical removal of dirt and oil, reduction of transient bacterial population (bacteria deposited by the environment) and residual depression of the skin's resident bacterial population (bacteria persistently isolated from skin) during the procedure. We cannot rely on sterile gloves alone. Up to 50% of gloves contain holes at the completion of surgery. This figure may increase with long or difficult surgeries.

The initial scrub easily removes dirt, oils and transient microflora. Resident microflora are considered to be permanent inhabitants of the skin eg the bacteria
present in the sebaceous glands and hair follicles, and these are substantially reduced by the action of the chemical solutions. The final application of a suitable chemical solution provides residual anti-microbial activity to inhibit bacterial growth during surgery.

Brushes are commonly used during the scrub procedure to facilitate the removal of dirt and skin scales containing bacteria. Brushes, especially if they are stiff or used with excessive force, can damage skin, leading to multiplication of skin bacteria and increased shedding into the environment. Skin Ph may also be increased, resulting in reduced antibacterial properties, changes in bacterial flora and chronic dermatitis.

Fingernails are kept short, clean and free of polish and artificial nails. All surfaces of the hands and forearms below the elbows are exposed to the antiseptic scrub for at least 2 minutes. Particular attention is paid to the area under the nails because this area has the highest bacterial count.

Iodine compounds are effective antimicrobial agents but have a limited activity against bacterial spores. Iodine solutions are used for surgical preparation, topical wound therapy and joint and wound lavage. Iodine compounds are available as aqueous solutions, tinctures, and iodophors. Aqueous solutions contain higher levels of free iodine than iodophors and therefore have higher bacterial activities. Dilution of stock solutions into 1:10, 1:50 and 1:100 concentrations increases bacterial activity and decrease cytotoxicity. Chlorhexidine is an antiseptic agent that is available in aqueous solutions (antiseptic solution for lavage purposes), tinctures (left on – final prep) and detergent formulations. It is an effective antimicrobial agent with activity against bacteria, moulds, yeast and viruses. Chlorhexidine has a rapid onset of action, and a long residual activity that is not affected by alcohol, lavage solutions or organic debris. As a lavage solution for open wounds, chlorhexidine must be diluted 1:40 to produce a 0.05% solution.

Alcohols are bactericidal but are ineffective against spores and fungi. They have no residual effect and are inhibited by organic debris. They de-fat skin and dry the skin through evaporation and should never be used on open wounds because they are both painful and cytotoxic. Ethyl and Isopropyl alcohol are most commonly used in practice.

Antimicrobial soaps or detergents used for scrubbing should be rapid acting, broad spectrum, and non-irritation. They should inhibit rapid rebound microbial growth. A good surgical scrub takes at least 4 minutes. Having a clock visible during the procedure is very helpful. Everyone should follow the same protocol. Surgical scrubs physically separate microbes from skin and inactivate them via contact with the antimicrobial solution. Two accepted methods of performing a surgical scrub are the anatomical timed scrub (4 minutes) and counted brush stroke methods (no. strokes per surface area of skin). Both methods ensure sufficient exposure of all skin surfaces to friction and antimicrobial solutions. Skin irritation or abrasions should be avoided because this can result in the
release of bacteria residing in deeper tissues (hair follicles). The first scrub of the day is usually the longest and subsequent scrubs take 2-3 mins. Three surgical scrub solutions are currently available; chlorhexidine gluconate, povidone-iodine or triclosan. Chlorhexidine continues to be the most popular choice, having a longer residual activity than povidone-iodine, a broad spectrum of activity against viruses, bacteria, fungi and sponres. It also provides an effective level of activity in the presence of organic matter. Once the scrub is started, nonsterile items must not be touched. If the hands or arms are inadvertently touched by a nonsterile object, the scrub must be repeated. Hands are always kept above elbow level to allow water and soap to flow from the cleanest area (hands) to the less clean area (elbow). A single scrub brush can be used for the entire procedure. No difference has been documented in the effectiveness of a sterilised reusable nail brush and disposable polyurethane brush/sponge combination.

**Turn on the water and adjust the temperature**

**Wet the hands and arms**

Dispense some of the scrub solution into the palms of the hands and commence washing, working up a lather. Clean nails. Continue to the arms up to and including the elbow. Rinse the hands and arms; keeps the hands above the elbows to allow water to drain from the elbows. Obtain a sterile scrub brush and wet it. Dispense some surgical scrub onto brush and begin to scrub the surfaces of one hand. Scrub the palm and four surfaces of each finger; Each surface is given 10 strokes of the brush. Do not scrub the back of the hand excessively as this can lead to excoriation and inflammation. I do not recommend scrubbing the arms with the brush either. Repeat for the second arm. Discard the brush into the sink. Rinse the hands and arms. Dispense surgical scrub solution onto the palms and wash hands and arms again, working towards but not touching the elbows, thereby avoiding contamination. Rinse the hands and arms again. Use a sterile towel to dry each hand and arm independently, starting with the hand and working to the elbow. Use a blotting action. Keep forearms and hands above waist level with hands together.

**Gowning**

Gowns are used to provide a barrier between the skin of the surgical team member and the animal. Ideally, they should be constructed of a material that eliminates the passage of microorganisms between sterile and nonsterile areas. They should be resistant to fluid, linting, stretch, pressure and friction, and should be comfortable, economical and fire resistant. Gowns are available as disposable non woven material or woven reusable fabrics.

Gowning and gloving should be done on a surface separate from other sterile supplies to avoid dripping water onto a sterile field and contaminating it. Gowning can start as soon the hands are dry. Gowns are always folded so that the inside of the gown is facing out. The surgeon lifts the gown carefully out of its sterile pack. The gown is held by the neck at shoulder height. Step back from the table and allow the gown to fall open. Be very carefully not to let the gown touch non-sterile surfaces. Advance both hands into the arms of the gown. An assistant then pulls the back of the gown over the shoulders and fastens the ties at the
back. The front of the gown must remain sterile. The hands should remain within the sleeves if closed gloving is to follow.

**Gloving**
Gloves are worn by the surgical team to protect the patient from microorganisms on the operating teams skin. Gloves provide a barrier that is not absolute. Some gloves have holes in them before they are even put on. The accepted industrial standard is that 1.5% of gloves will have holes in them before they are used DM Fogg JAAHA 10:58, 1974. Another study filled latex gloves with water and found 2.7% of unused gloves had leaks Korniewicz D Nur Res 38:144, 1989. Gloves are susceptible to punctures or tears during use. By the end of surgery, up to 31% of gloves have perforations RD Dodds Br J Surg 77:219, 1990. The incidence of perforation was higher in orthopaedic surgery than soft tissue surgery. Surgical hand scrubs probably reduce bacterial counts and suppress bacterial multiplication so that contamination of the surgical wound on puncture of a glove is not significant. It is still recommended to replace torn/punctured gloves as soon as noticed. Powders are used within gloves to make it easier to put them on. Talc can cause acute inflammation following by a chronic persistent granulomatous reaction when it is put into a surgical wound. However, they are not a substitute for proper scrubbing methods. If the glove of a properly scrubbed hand is perforated during a surgical procedure, bacteria are rarely cultured from the punctured glove. Lubricating agents for latex gloves such as magnesium silicate (talcum) or low cross-linked cornstarch allow gloves to slide more easily onto the hand. These agents cause considerable irritation to various tissues, even if gloves are vigorously rinsed in sterile saline before surgery. Therefore, the surgeon should use gloves in which the inner surfaces are lubricated with an adherent coating of hydrogel. There are three techniques for gloving – open, closed, and plunge or assisted gloving. Any of these methods is acceptable provided asepsis is maintained throughout the procedure. The closed method is one of the most popular as there is less risk of any contamination. The plunge method involves a scrubbed assistant holding the gloves open and is used when replacement gloves are needed during surgery. This is rarely practiced.

**Open gloving:** the hands are extended out of the sleeves of the gown. The right hand glove is picked up at the turned-down cuff with the thumb and forefinger of the left hand. The glove is pulled onto the hand without unfolding the cuff. The gloved right hand picks up the left glove by sliding under the folded down cuff. The left hand is slipped into the glove and the glove cuff is unfolded and pulled over the cuff of the gown. The left hand is used to complete the gloving of the right glove. Fingers are adjusted as needed. Gloved hands must remain about waist level.

**Closed gloving:** The cuffs of the gown should cover the fingers in this method. The right glove is placed on the right sleeve with the cuff of the glove lying on the cuff of the sleeve and the thumb of the glove placed close to the hand. The right hand holds the right glove by the rim of the folded cuff. The left hand grasps the rim of the right glove and pulls it over the circumference of the right hand and cuff of the gown. The left hand then pulls the right glove cuff gentle and the
fingers are pushed into place using the glove cuff and the sleeve of the gown. The left glove is applied in a similar manner.

**Surgical wound infection and the use of antimicrobials**

Infection rates after routine surgery are typically low, provided high standards of asepsis are maintained. The estimated wound infection rate associated with surgery in small animals is 5.5% (D Brown et al JAVMA 210:1302, 1997)

Infection is a common cause of post operative discomfort, costly intervention, prolonged hospitalisation, and potentially death. Prophylactic antibiotics have become very common in current practice. However, antibiotics are no substitute for aseptic preparation, careful surgical technique and good post operative care. Inappropriate use of antibiotics or excessive use of antibiotics can result in higher costs to the client and the development of antibiotic resistance.

Determinants of wound infection – host factors and factors prior to surgery and during surgery.

- **Host factors:** Medical health, age (>8yrs old), poor body condition score, individual illnesses may not add to infection risk in animals as it does in humans.
- **Surgery factors:** length of procedure. Risk of postoperative infection rate is twice as high for animals undergoing a 90 minute procedure as it is for animals undergoing a 60minute procedure. The risk of infection doubles with every hour of surgery (D Brown et al JAVMA 210, 1302, 1997). For each additional hour, there is a 30% increased risk of wound infection (E Heldmann et al Vet Surgery 28, 256, 1999). Indeed, this study highlighted an increased risk of surgical wound infection in animals administered propofol anaesthesia (lipid based emulsion capable of supporting microbial growth and administration of contaminated solution may cause a temporary bacteraemia). Surgical sites clipped prior to anaesthesia have an increased risk of infection. Brown et al JAVMA 210, 1302, 1997. Older animals (>8 yrs) and animals with body condition scores other than normal tend to exhibit higher infection rates.

Remember, all surgical wounds will be contaminated. Fortunately, this does not result in wound infection. Incisional wound infections usually develop within 30 days of surgery or within 1 yr if an implant is placed.

What determines wound infection?? Number and pathogenicity of the bacteria present in the wound, the presence of intact host defenses, the local wound environment and the surgical technique.

The ability of bacteria to infect a wound depends on a critical level of contamination (10 to the power of 5 organisms per gram of tissue). Remember, not all bacteria are of equal virulence and pathogenicity. Most animals with a normal immune system will overcome this bacterial contamination level and thus prevent wound infection. The surgical wound incision results in a normal host inflammatory response: rapid increase in capillary permeability. Red and white cell types pour into the surgical wound providing an immune response.
against contaminating bacteria. Primary closure of the surgical wound is performed and a small compartment of serohaemorrhagic exudate remains within the incised tissues. High number of neutrophils are the first cell type released and phagocytose bacteria. Macrophages follow to debride the wound.

Local wound factors heavily influence the risk of surgical wound infection. The presence of blood clots, ischaemic tissue, pockets of fluid and foreign material prolong the inflammatory phase of wound healing and indeed inhibit normal body defense mechanisms. These factors reduce the number of bacteria required to establish an infection in a surgical wound. DE Johnson Vet Clin North Amer 20:1 1990 J Romatowski JAVMA 194, 107, 989. Simply using braided material reduced the number of Staph Aureus required to produce infection RJ Howard In Schwartz SI (ed) Principles of Surgery 7th ed McGraw-Hill, New York, 1999, p 123. Seroma and fluid increase the risk of wound infection due to the inhibition of phagocytosis. RJ Howard ... Minimising dead space in a surgical wound with anatomical apposition of the tissue and the selective use of drains will minimise fluid formation within a wound. Good haemostasis, copious warm saline lavage, gentle tissue handling, anatomical tissue apposition, correct suture selection will all potentially reduce the risk of surgical wound infections.

Recommendations for prophylactic antimicrobial administration in veterinary medicine are based on the National Research Council wound classification system used in humans, which categorises surgical wounds based on the extent of operative contamination CP Page et al Arch Surg 128, 79, 1993
<table>
<thead>
<tr>
<th>Classification</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>Non traumatic</td>
</tr>
<tr>
<td></td>
<td>No inflammation encountered</td>
</tr>
<tr>
<td></td>
<td>No break in technique</td>
</tr>
<tr>
<td></td>
<td>Resp, GI, genitorurinary not entered</td>
</tr>
<tr>
<td>Clean-contaminated</td>
<td>Resp., GI entered without spillage</td>
</tr>
<tr>
<td></td>
<td>Oropharynx entered</td>
</tr>
<tr>
<td></td>
<td>Vagina entered</td>
</tr>
<tr>
<td></td>
<td>Genitourinary entered (no infected urine)</td>
</tr>
<tr>
<td></td>
<td>Biliary tract entered (no infected bile)</td>
</tr>
<tr>
<td></td>
<td>Minor break in technique</td>
</tr>
<tr>
<td>Contaminated</td>
<td>Major break in technique</td>
</tr>
<tr>
<td></td>
<td>Gross spillage from GI</td>
</tr>
<tr>
<td></td>
<td>Traumatic fresh wound</td>
</tr>
<tr>
<td></td>
<td>Genitourinary or biliary tract entered (infected fluid)</td>
</tr>
<tr>
<td>Dirty</td>
<td>Acute bacterial inflammation</td>
</tr>
<tr>
<td></td>
<td>Transection of clean tissue to access infected area</td>
</tr>
<tr>
<td></td>
<td>Traumatic wound with devitalised tissue, FB, faecal contamination</td>
</tr>
</tbody>
</table>

The use of antimicrobials in clean wounds continues to be controversial. Prophylactic antimicrobials are not indicated in clean surgical procedures of short duration. Currently, prophylactic antimicrobials may be considered for clean procedures with long duration (>90 mins), where surgical implant is placed, or where infection would be considered catastrophic eg THR, TPLO etc.

T Whittem et al JAVMA 215, 2122, 1999

Prophylactic antimicrobials are recommended for clean contaminated, and selected contaminated wounds. Dirty wounds require therapeutic antimicrobial administration.

Unrestricted use of antimicrobials has resulted in an increased risk of superinfection and the development of resistant organisms. The surgeon must become familiar with the indications for the use of antimicrobials and familiar with the mechanisms of action of the commonly used drugs. Each surgical case should be considered individually to determine if antimicrobial therapy is indicated.

Prophylactic antimicrobial therapy implies the delivery of the agent prior to the surgical incision being made, ie before contamination of the wound. Appropriate levels of the antimicrobial agent should be present within the local blood supply of the proposed surgery site before surgery begins. The aim is to achieve and maintain inhibitory antimicrobial concentrations for the duration of the procedure. The selection of the prophylactic antimicrobial drug depends on the
most likely microbial contaminant within the surgical wound, cost, drug toxicity, and patient health factors. The most common source of bacterial contamination of a surgical wound is the animal itself rather than the environment or surgeon. Members of the penicillin or cephalosporin families are typically used in veterinary surgery because of their efficacy against most surgical wound pathogens, low toxicity, reasonable cost, and minimal side effects.

Prophylactic antimicrobials should be administered intravenously 30-60 minutes before a surgical incision. DM Boothe et al In Osborne CA (ed) Current veterinary therapeutics XIII WB Saunders Philadelphia, 2000, 33 JA Johnson and RJ Murtaugh Comp Contin Educ Vet Prac 19,693, 1997. There is a time lag between peak serum and surgical wound levels. Antimicrobials given 3 hours after bacterial contamination have been shown to have no beneficial effect in controlling infection CE Green In Greene CE (ed) Infectious diseases of the dog and cat 2nd ed WB Saunders Phil 1998 p 343

Subcutis or intramuscular injections of antimicrobials are dependent on hydration status of the patient and should be administered at least 2 hrs before surgery is performed.

Adequate tissue concentrations must be maintained throughout the surgical procedure. The current recommendation in humans is that the timing of additional intraoperative administrations should be based on one or two times the elimination half-life of the drug EP Dellinger et al Clin Infect Dis 18, 422 1994 Cephalosporins at 22mg/kg is recommended every three hours in dogs, although numerous publications will cite 90 mins for orthopaedic surgeries and 120 minutes for soft tissue procedures. The necessity for this increased frequency has not been supported in either the veterinary or human literature. At this stage there is no evidence to support the need for antimicrobial administration beyond the operative period EP Dellinger et al Clin Infect Dis 18, 422 1994, E Rosin et al Am J Vet Res 54, 1317, 1993
<table>
<thead>
<tr>
<th>Operation</th>
<th>Common bacteria present</th>
<th>Suggested Antimicrobial</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>General orthopaedic</td>
<td>Staph Intermedius</td>
<td>Cephalosporin</td>
<td>22mg/kg q 3hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Penicillin</td>
<td>70,000 U/kg q 3 hrs</td>
</tr>
<tr>
<td>THR</td>
<td>Staph Intermedius</td>
<td>Cephalosporin</td>
<td>22mg/kg q 90hrs</td>
</tr>
<tr>
<td>Cardiopulmonary</td>
<td>Staph Intermedius</td>
<td>Cephalosporin</td>
<td>22mg/Kg q 3hrs</td>
</tr>
<tr>
<td>Coliforms</td>
<td></td>
<td>Cephalosporin</td>
<td>22mg/kg q 3</td>
</tr>
<tr>
<td>Colorectal</td>
<td>Cliforms, Anaerobes</td>
<td>Neomycin</td>
<td>6mg/kg SID CARE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Erythromycin</td>
<td>10-20mg/kg PO BID/TID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cephalosporin</td>
<td>22mg/kg q 3 hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metronidazole</td>
<td>20mg/kg IV TID</td>
</tr>
<tr>
<td>Neuro</td>
<td>Staph Intermedius</td>
<td>Cephalosporin</td>
<td>22mg/kg q 3hrs</td>
</tr>
<tr>
<td>Liver/biliary</td>
<td>Coliforms, Anaerobes</td>
<td>Cephalosporin, Metronidazole</td>
<td>22mg/kg q 3hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10mg/kg IV TID</td>
</tr>
<tr>
<td>Urogenital</td>
<td>E Coli, Strep spp, Anaerobes</td>
<td>Cephalosporin, Enrofloxacin, Metronidazole, Ampicillin</td>
<td>22mg/kg q 3hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22mg/kg q 3hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5mg/kg q 2hrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20mg/kg IV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20mg/kg IV</td>
</tr>
</tbody>
</table>

Time consuming and complicated operations generally involve more extensive preparation, extensive diagnostic procedures, longer and more extensive tissue manipulation, increased use of sutures and electrocautery, all of which reduce local resistance of the wound MW Beal et al Vet Surgery 29, 123; 2000. Furthermore, prolonged anaesthesia in humans resulted in altered immune responses – macrophage, neutrophil, lymphocytes etc. Beal 2000, J Ciepichal and A Kubler Arch Immunol Ther Exp 46, 183, 1998.
**Sutures**

The consequences of suture material implantation upon wound healing depend on the nature of this material (composition, diameter), on the needle used, suture technique and the amount of suture material implanted.

Remember, suture material is foreign material within a wound. It will interfere with wound healing. Suture material is used to improve local wound healing conditions.

Suture material placement causes a local tissue reaction which depends on the amount and type of suture material used, and the surgical technique used to place the suture. Natural sutures cause a more significant local tissue reaction when compared with synthetic material. Natural absorbable sutures rely on enzymatic and cellular reaction. Synthetic absorbable materials are degraded by hydrolysis – a non-inflammatory response. The quantity of any suture material implanted in a wound is directly proportional to its diameter and the suture pattern used (interrupted/continuous). Suture material placement exerts tension across the closed wound edges. Avoid excessive tension (results in pain, tissue ischaemia, tearing of the tissue) and uniform placement of the sutures along the edge of the wound is critical.

Suture materials are made up of monofilament or multifilament structures. Multifilament suture material has a rougher and wider diameter when compared with monofilament suture material of the same size. Multifilament sutures are capillary and allow a ‘wick effect’. These suture material are now coated to make their surfaces more regular and to decrease their capillarity and ‘tissue drag’. Bacteria will adhere to the surface of suture material, particularly on uneven and large material. Braided suture material is contra-indicated in contaminated/infected wounds. Select a monofilament material and minimise the amount of suture material present by limiting the amount implanted and select the lowest diameter possible.

**Main Knots:**

- Slip knot
- Square knot
- Granny knot
- Surgeons knot

The square knot is the basic knot in surgery. Not too much tension on the first throw. If excessive tension present and the first knot will not hold, consider the slip or surgeons knot. Be cautious when placing a surgeons knot around a vascular structure – it may not be tight enough!
Square knots are always less likely to slip than a granny knot; consequently, less throws are required to secure a square knot. Square knots are preferred. Poor technique in creating a square knot can result in slip knot formation (slip knots require a locking technique and additional throws). The creation of slip knots instead of the intended square knots is the most common reason for knot slippage in surgery.

Slip knots can be created intentionally to allow progressive tightening of a loop. This characteristic is particularly useful for the ligature of deep structures; the throws are formed outside the operative field and the knot then advanced to the bottom of the wound. It is important to realise that these knots are more prone to slip than other knots. Safety is theoretically never reached!! A minimum of 5 throws is required. Alternatively, place 2/3 square throws above the slip knot to lock it.

The safety of any knot relies on the suture (composition and diameter), ligation technique (knot type and tension) and on the wound (tension, moisture). Increased friction on the surface of a suture will reduce the risk of slippage. Braided sutures have a higher coefficient of friction than monofilament ones. Knots made with braided sutures are safer.

Sutures using excessively small diameter material are more likely to cut the tissue it apposes. Using too large a suture diameter will often result in poor knot tightening.

Avoid handling/crushing the suture length to be used with needle-holders or haemostats.

<table>
<thead>
<tr>
<th>SUTURE MATERIAL</th>
<th>Interrupted pattern</th>
<th>Continuous pattern Start</th>
<th>Continuous pattern end</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polydioxanone</td>
<td>4</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Poliglactin 910</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Poliglycolic acid</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Polyamide</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Number of throws necessary for the knot to be safe using USP 2-0 suture

The ideal suture material

a) high initial tensile strength until sutured tissues heal and regain sufficient tensile strength
b) loss of tensile strength predictable
c) inert – both electrically and biologically
d) non – allergenic
e) non – carcinogenic
f) non – toxic
g) not support bacterial growth
h) absorbed or encapsulated when no longer useful
i) excellent handling characteristics
j) no memory
Suture selection must consider characteristics of the wound to be closed. Sutures are classified according to their origin, the number of strands in the suture, and their persistence in tissue.

**Tensile Strength**

Tissues have an intrinsic resistance to suture pull through and this is directly proportional to their collagen content. Fascia, ligaments, tendons and skin are the most resistant. The hollow organs and muscles have an intermediate resistance and the least resistant are parenchymatous organs such as the liver, spleen, kidneys or lung. The ideal suture material must have an initial resistance near that of the tissue to be sutured.

Most resistant tissues are the slowest to heal and thus regain their definitive resistance (except skin). The loss of tensile strength of sutures should be inversely proportional to the scar tissue gain of strength. Tissues that are slow to heal and gain resistance should be closed using nonabsorbable or slowly absorbed sutures with great initial tensile strength.

In a contaminated wound, the suture must be as biologically inert as possible. Braided material should be avoided. The amount of suture material implanted must be as low as possible – using small diameter suture material. Interrupted suture patterns are preferred. Continuous suture patterns because contamination can spread along the length of suture material. The length of time needed for the tissues to heal will determine whether absorbable or nonabsorbable suture material is selected.

**Suture properties**

**Natural or synthetic**

Historically, the first suture materials were of natural origin (silk, cotton or catgut for example). Today synthetic materials have widely replaced them.

Natural sutures originate from animal or vegetable material. They are degraded by phagocytosis which results in an inflammatory response around the suture material. If these sutures are placed in an already contaminated/infected area, absorption can be even faster than normally expected. Catgut was extensively used as an absorbable suture in human and veterinary surgery. It is now infrequently used and not recommended for general use in veterinary surgery. Silk sutures are still used, particularly for vascular surgery. They are considered nonabsorbable but in fact are absorbed after approximately 2 years. This material is capillary and induce a strong tissue reaction.

Synthetic sutures are produced by polymerisation and are absorbed by hydrolysis which induces little tissue reaction.
Monofilament or multifilament sutures
Monofilaments are composed of only one strand of material. They are less traumatic due to their low coefficient of friction, when placed through tissue. They have more memory resulting in less favourable handling qualities. Knot security can be poor with monofilament sutures. These characteristics are changing with recent products. Monofilaments have better handling characteristics and better knot security than earlier products.

Multifilament sutures are typically of braided composition. They are rougher, capillary, flexible, and without memory. Their handling and knot security are good. More recent products of multifilaments are ‘coated’ to reduce tissue drag and capillary.

Absorbable and nonabsorbable
The classification of suture material depends on the rate of loss of tensile strength. An absorbable suture material whose mechanical resistance decreases within 60 days of implantation is regarded as absorbable. In contrast, a material whose mechanical resistance is constant within 60 days of implantation in tissue is regarded as nonabsorbable.

Where possible, absorbable sutures should be used for internal tissue closure. The absorption time is the time it takes for the suture to completely disappear from the tissues. The resistance time is the time during which the suture still has any mechanical resistance within tissues, however low it may be. The effective time is the time during which the suture preserves at least 50% of its mechanical resistance.

Absorbable suture materials

<table>
<thead>
<tr>
<th></th>
<th>Effective time</th>
<th>Resistance time</th>
<th>Absorption time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monofilament</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glycomer 631 (Biosyn)</td>
<td>18 days</td>
<td>30 days</td>
<td>90-110 days</td>
</tr>
<tr>
<td>Poliglecaprone 25 (Monocryl)</td>
<td>14 days</td>
<td>21-28 days</td>
<td>90-120 days</td>
</tr>
<tr>
<td>Polydioxanone (PDSII)</td>
<td>28 days</td>
<td>60 days</td>
<td>180-210 days</td>
</tr>
<tr>
<td>Polyglyconate (Maxon)</td>
<td>21 days</td>
<td>30 days</td>
<td>180 days</td>
</tr>
<tr>
<td><strong>Braided Suture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyglycolic acid (Dexon)</td>
<td>7 days</td>
<td>14 days</td>
<td>100-210 days</td>
</tr>
<tr>
<td>Lactomer 9-1 (Polysorb)</td>
<td>21 days</td>
<td>25-28 days</td>
<td>60-70 days</td>
</tr>
<tr>
<td>Polyglactin 910 (Vicryl)</td>
<td>15 days</td>
<td>35 days</td>
<td>56-70 days</td>
</tr>
<tr>
<td>Polyglactin 910 irradiated (Vicryl Rapide)</td>
<td>5-7 days</td>
<td>14 days</td>
<td>42 days</td>
</tr>
</tbody>
</table>

**Rapidly absorbable braided sutures lose half their tensile strength in 1 wk and all of it in 2 wks** eg Dexon and Vicryl rapide

**Slowly absorbable braided sutures and absorbable monofilaments lose half their tensile strength in 2 and 3 wks, and all of it in 4 wks** eg Vicryl and Polysorb, Monocryl and Maxon
PDS II lose half their tensile strength in 4 wks, and all of it in 2 months – twice as long as other absorbable

The most common nonabsorbable monofilaments are polyamidess (nylon) or polymers of propylene (polypropylene). Non absorbable braided materials are mainly polyesters.

The diameter of a suture can be described according to two main conventions: **Metric** – suture diameter expressed in tenth of millimetres (eg 2 metric is 0.2mm). The metric size of a suture indicates the minimum diameter of the suture. **USP** – United States Pharmacopoeia. Size is based on tensile strength of the suture rather than physical diameter. Size 11-0 is the smallest/weakest up to Size 7.

It is recommended to use sutures of the lowest suitable diameter. Remember, the trauma caused by passage through tissues, the size of the knot and tissue reaction of the suture all depends on suture diameter selected. The knot security of a smaller diameter suture is always tighter. There is a tendency to select a suture that is too large due to a lack of confidence and awareness.

The smallest suture of sufficient tensile strength must be chosen, provided its tightening will not cut tissues.

Handbook of ligatures and sutures in veterinary surgery Laurent Findji and Gilles Dupre
Wound Management

All wound management needs to be done as part of the overall patient assessment. Traumatic wound require careful assessment of the patient before intensive wound management is initiated. Protect the wound to prevent further injury or contamination. Some form of stabilization may be required if fractures or joint instability are present. Sterile dressing should be used. After the patient has been stabilised, assess the wound carefully. Bite wounds can be very deceptive in gross appearance. The level of tissue damage can usually be established within 24hrs of the injury. Systemic antibiotics are considered if muscle and fascia are damaged, if the animal is immunocompromised, or if signs of local or systemic infection exist.

Cover wound with a sterile water-soluble ointment and clip the area surrounding wound carefully. Use a scissors with water-soluble gel/ointment on the blades to clip the hair on the edge of a wound. Flush the wound carefully and copiously – 500ml sterile saline via 35 – 50ml syringe, 3-way tap and 18/19g hypodermic needle. Lavage allows the physical removal of debris and foreign material from the wound, by applying large volumes of fluid under moderate pressure. The ideal lavage fluid in isotonic, sterile, non-cytotoxic and economical to use in large volumes eg Lactated Ringers, Sterile saline. For initial lavage of a dirty/contaminated wound tap water may be considered using a gentle spray device. Antibiotic solutions are not necessary. If antimicrobial action is required 0.05% chlorhexidine gluconate solution is best as it has good antimicrobial activity with very good residual activity and a low potential for cytotoxicity.

After lavage, surgically remove exudates, necrotic debris and non – viable tissue in the wound. Successful debridement requires the accurate identification of viable tissue (colour, arterial pulse, presence of bleeding). Sharp excision with a blade is preferred to a scissors. If in doubt about tissue viability be conservative and review in 24 hours. Therefore repeated daily assessments of a wound are important, with staged debridement often necessary. Chemical debridement involves the use of chymotrypsin or trypsin but is rarely used. Any damage to tendons, supportive ligaments or major nerves should be identified and surgical repaired as soon as the patient is stable.

Further debridement of the wound may be necessary if contamination is still present. This can be performed using wet – to – dry dressings. This is referred to as mechanical debridement. Sterile gauze swabs are soaked with sterile saline, squeezed of excess moisture and then placed on the wound. A secondary absorptive layer is placed followed by an outer protective layer. The gauze swab will adhere to the wound surface as it dries out. This beneficial feature can be used to gently debride the surface of the wound. Bandage changes are performed 24 – 48 hourly depending on the wound, and will require good analgesia and sedation. This type of bandaging is normally used from the 1st to the 3rd/5th day in managing the wound. Wet – to – dry dressings are not performed in the presence of healthy granulation tissue and epithelisation. After day 3/5 no additional mechanical debridement is usually required. At this stage hydrogel and a non – adherent dressing such as Melanin, Allevyn may be used. Hydrogels maintain a moist environment and increase oxygen tension within the wound. This facilitates autolytic debridement by inflammatory clees and also preserves viable epithelial
and deeper cells. Non-adherent dressings – allevyn, melolin – are less traumatic to the wound tissues, allow absorption of exudates and keep wounds moist with good oxygen tension.

Wound may be closed immediately after debridement (primary closure), or 3 – 5 days later (delayed primary closure) when remaining contamination has been removed. This is preferable to prolonged dressing changes and gradual wound contraction and closure (second intention healing) which is time consuming and expensive. Many techniques can be used to facilitate closing wounds under tension – release incisions, local flaps, skin grafts and axial pattern flaps.

Drains are used to obliterate dead space and/or remove potentially harmful material from the wound. Passive drains are most frequently used and rely on gravity flow and capillary action. Penrose drains are flat latex passive drains of various diameters. These drains are less traumatic to tissues than tube drains. Penrose drains should not be fenestrated. These drains are placed within the wound and exit the skin at one point only. They rely on gravity to pull fluid along the surface of the drain to the exit point which is located distally, away from the wound edge. Sterile placement of drains is important and may be covered in a sterile bandage until removal. Use the least number and smallest diameter drains to provide adequate drainage. Remember, the exit hole for the drain should be separate from the surgical incision. Drains are removed when no longer required – this decision is based on daily assessments of the amount and character of drainage from the wound. All drains will induce a foreign body reaction, with a small amount of clear fluid. Passive drains are simple to use, inexpensive, and can be used on an outpatient basis. Active drains have the advantage of a more rapid effect. A negative suction drain tube is placed within the wound. They are not dependant on gravity pull and can exit the skin at any location around the wound.

Elizabethan collars should be used to protect the wounds during management.

Antibiotics are normally continued 3 - 5 days after presentation, but this has to be decided on a case – by case basis.

**Principles of wound closure**

Improper wound closure is one of the biggest mistakes made in the early management of traumatic wounds. Wounds are often closed too soon, only to result in complications. Surgical manipulation of recently traumatized skin should be minimized until circulation improves. Resolution of contusions, oedema, and infection indicates improved skin circulation. During the first 6-8 hours after injury, only wounds classified as clean, or clean-contaminated should be considered for immediate closure. All other wounds should be managed appropriately for 1-3 days and will become better candidates for closure.

Before closing a large trunk wound, consider the lines of tension. Pick up the surrounding skin to assess elasticity and direction of possible primary closure. Undermining skin edges will reduce wound tension. Skin should be undermined deep to the panniculus muscle to preserve the subdermal blood plexus and direct cutaneous vessels. There is no panniculus muscle layer in the middle and distal
portions of the limbs. Skin in undermined in the loose areolar fascia fascia deep to the dermis to preserve the subdermal plexus. Undermining is kept to a minimum.

The primary factors in determining the reconstructive technique of choice include inherent vascularity of the wound, exposure of vital structures – joints, fractures, bone, anatomical locations and wound size.

Secondary intention healing can be considered for superficial wounds involving less than 30% circumference of the limb. Skin has viscoelastic properties that can be used to reconstruct wounds. Preplacing tension sutures over a wound 72-96 hrs before surgery can result in significant reduction in resistance to tensile forces. This can allow skin to be advanced over a wound with far less tension than without skin tensioning. Multiple punctuate releasing/relaxing incisions placed in parallel rows surrounding the wound can be used to allow skin advancement of skin edges. Staggering of relaxing incisions helps to ensure vascularity of skin margins. Tissue expanders have an inflatable bag and reservoir made of silicone elastomer. These are placed and inflated in subcutaneous tissues to stretch the overlying skin, allowing creation of larger flaps for closing defects. This process can take days to weeks to prepare suitable tissue laxity. Skin grafts are segments of epidermis and dermis that are completely detached from the donor site and transferred to a recipient site. Survival of the skin grafts depends on early fluid absorption, followed by revascularisation and development of a fibrous attachment at the recipient site. Successful skin grafting is dependent on a healthy, well-vascularised and stable wound environment. Skin grafts are considered on the distal limb where there is a healthy granulation wound. Skin grafts are classified as full or split thickness. Full thickness skin grafts incorporate the entire dermis and epidermis. Split thickness skin grafts may be further classified as thin, intermediate, or thick split-thickness grafts depending on the relative thickness of dermis incorporated into the graft. Split-thickness grafts are rarely indicated in reconstruction of wounds in small animals.

Skin grafts are classified as sheet, mesh, strip or seed grafts. Mesh grafts are formed by placing multiple staggered rows of parallel incisions through the graft. Mesh grafts can be expanded when placed on the recipient bed. Expansion of the mesh graft allows wound reconstruction with less graft material and ensures adequate wound drainage. Full thickness mesh grafts are preferred for most wound reconstructions based on their ease of use, success of graft take, and final cosmetic outcome.

Skin Flaps are ‘tongues’ of epidermis and dermis that are partly detached from donor sites and used to cover defects. The base of the flap contains the blood supply essential for flap survival. Skin flaps are classified according to location, blood supply, and geometric shape. Most flaps are called subdermal plexus flaps. Those with direct cutaneous vessels are called axial pattern flaps. Increasing the width of a pedicle flap does not necessarily increase the surviving length of the flap. Narrowing the base of the pedicle increases the risk of necrosis. Pedicle flaps are made up of advancement flaps, rotational flaps, transpositional flaps etc. Axial pattern flaps are based on direct cutaneous artery and vein supplies at the base of the pedicle. These flaps have very good perfusion and can be rectangular or L-shaped.