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Reducing surgical site infections (SSI)

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ABSTRACT: Surgical site infections can have a significant effect on quality of life for the patient. They are associated with considerable morbidity and extended hospital stay. In addition, they result in a significant financial and emotional burden to owners.

This article will focus on the preparation of the patient for surgery and measures that can be taken to limit the spread of infection within the operating theatre.

Surgical site infections (SSI) occur in wounds after an invasive (surgical) procedure, they lead to an increased morbidity and – in some cases – mortality. A surgical site infection may range in severity from a wound discharge arising within 7–10 days of an operation, to a life-threatening postoperative complication.

Most surgical site infections are caused by contamination of the incision with microorganisms from the patient's own body during surgery. Infection caused by microorganisms from an outside source following surgery is less common.

The majority are preventable and measures can be taken throughout the perioperative period to reduce the risk of infection. Veterinary nurses are well placed to ensure high standards of hygiene are met and maintained.

Prevention is better than cure

It is pointless for a veterinary surgeon to perform amazing feats of surgery if infection control has not been considered and taken seriously. There should be protocols in place, which are followed by the whole practice team and aimed at preventing postoperative infections before they occur.

Whilst all surgical procedures carry a risk of acquiring a SSI, various factors will increase this risk. For example, the use of implants in surgery can increase the risk of infection owing to the presence of a foreign material.¹

Important areas to consider when focussing on surgical asepsis are:

- control of infection in the operating room
- patient preparation
- prevention of hypothermia
- personnel dress and theatre conduct
- hand hygiene
- equipment cleaning and sterilisation
- tissue handling
- antibiotic use
- postoperative care
- monitoring infection control measures.

Control of infection in operating theatre

In order to maintain a high level of cleanliness within any area of the veterinary practice, it is important to have a written protocol which is followed, taught and upheld. The theatre protocol should have clear guidelines outlining what needs to be done at the beginning and end of each day and between patients.

To enable theatre standards to be maintained, it is advisable to ensure there is limited clutter within the room and that flat surfaces are kept to a minimum, as these are prime areas for dust and biological matter to gather and thus increase the risk of cross contamination.

Any visible soiling with bodily fluids should be cleaned immediately with a

To cite this article use either
DOI: 10.1111/vnj.12045 or *Veterinary Nursing Journal* Vol 28 pp211–217

hospital grade disinfectant. The process of cleaning will remove organic matter, allowing the application of disinfection to kill the microbes present on the surface. All disinfectants need to be prepared and used according to manufacturer's guidelines to ensure efficacy.

Patient preparation

As veterinary nurses, we play a major role in surgical skin preparation. Our patients are usually the primary source of pathogens involved in SSI.^{2 & 3}

Even with our best efforts, surgical wounds will become contaminated with bacteria, but not all will become infected. This is because a critical level of bacterial contamination is required before infection occurs.

Whilst we can ensure that we prepare our patients to a high standard, there are many other factors that determine whether a contaminated wound will become infected. These include the host's own level of resistance.

Patients are the main cause of bacterial contamination, because their skin harbours two major groups of microorganisms called 'transient and 'residual' flora.

Transient flora

Transient (or temporary) skin flora are microorganisms such as bacteria, fungi and viruses that colonise the skin for a limited period. They can be spread by direct skin-to-skin contact or indirectly via objects. Hand disinfection is primarily aimed at deactivating transient flora, which can be almost completely eliminated by effective asepsis.

Resident flora

The resident flora are the physiological skin flora, also known as 'colonising flora'. They comprise bacteria such as *Staphylococcus epidermidis*, which do not have a pathogenic effect on the skin, but may cause infection following surgery or other invasive procedures.

It is not possible completely to eliminate resident flora from the skin – approximately 20 per cent of these microorganisms are inaccessible to skin disinfection because they are sequestered in the deeper layers of the skin, within the hair follicles and sebaceous glands.⁴

There is an added complication in that during surgery microorganisms

tend to repopulate an area following decontamination and this occurs at a much quicker rate than the original colonisation took place.⁵ This represents a significant risk of wound contamination which highlights the importance of correct selection of skin preparations.

We will never be able to make the skin a completely sterile area, but our aim should be to free the surgical site from microorganisms as much as possible prior to surgery.

Methods of doing this include:

- bathing the patient
- hair removal
- surgical scrub

Bathing

For patients that are grossly contaminated pre-operative grooming and bathing may be required in order to remove gross matter, excess hair, skin scales and external parasites. Ideally this will be performed by the owner, if they are capable and compliant; otherwise you may offer to admit the patients so that you can perform this in the hospital.

This will also provide a good opportunity to check the patient's skin condition and flag up any areas of concern. If a patient has any sign of skin disease adjacent to the anticipated surgical site, it may be necessary to delay surgery whilst the skin is treated to reduce the increased risk of SSI.

General cleaning protocol for operating room

- Put on disposable gloves and wipe down all operating room fixtures, furnishings and equipment with a clean, *sterilised cloth* and a hospital-approved antibacterial, germicidal cleaning agent (such as Distel) prior to theatre use each morning.
- Then, using a hospital grade disinfectant the floor should be thoroughly mopped. Ensure that mops in theatre are only used in theatre. A simple colour coding system can be very effective to ensure that allocated cleaning equipment is retained in different areas of the practice:
 - When mopping, ensure that the mop is sufficiently wrung out such that it is damp. A damp mop will allow the dirt to cling to it instead of being spread around by the water on the floor.

Start in the corner farthest away from the door. Mop in a figure-of-eight pattern to utilise your mop most effectively and prevent dirt being pushed and left in the edges of the room.

As you mop, move towards the entrance of the room so you are always standing on a dry piece of floor. This will help to avoid recontamination. Change the solution often to ensure the water you're using to clean is not overly saturated with dirt. Dirty solutions will only move dirt from one area to another; they will not remove it from the floor.

- The room should be cleaned between each operation. Begin by bagging and removing all cloth items, such as surgical drapes and hospital linens. Gather all gowns, shoe covers, masks, gloves and other disposable items and remove them from the operating area, then dispose of them appropriately.
- Wash, sterilise and replace any items used during the surgical procedure. Also, clean any large pieces of equipment that may have been handled physically by the surgical team – such as trays and light fixtures – with an antibacterial germicidal cleaning agent.
- When cleaning the floor, pay particular attention to the area where the surgical team works.
- Remove any furniture from the operating room and run a dust mop over the floor to collect any loose debris prior to vacuuming. Then, using a hospital-grade disinfectant, the floor should be thoroughly mopped (see above).
- Soak up any damp areas and allow the floor to dry.
- Once the floor is completely dry, return furniture to the room.

Pre-operative bathing has been shown to temporarily increase the bacterial load on the skin surface and, therefore, the decision to bath patients prior to surgery will not be routine but based on the individual patient's degree of contamination and the procedure being performed.

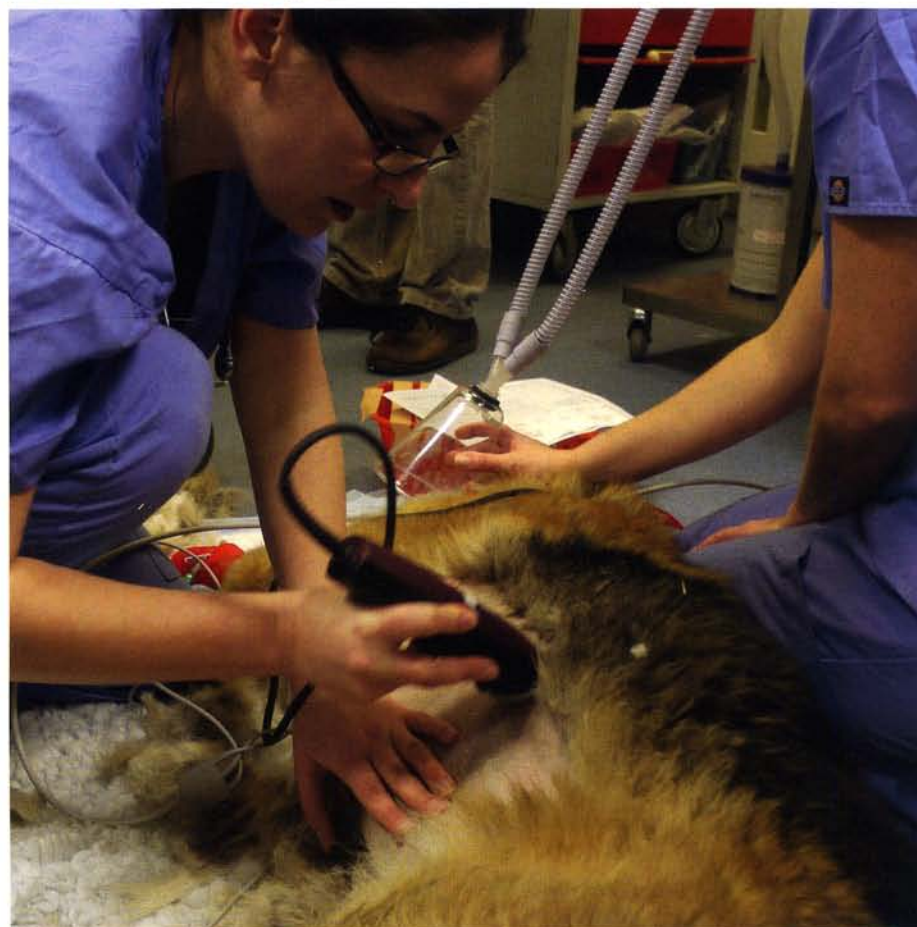
Hair removal

Hair removal is the most effective way of achieving surgical skin preparation. Hair is a significant reservoir for microbes and organic matter and should it enter the surgical site, it will act as a foreign body.

Generally, clipping is carried out once anaesthesia has been induced. The only exception to this is in the emergency setting when a 'rough clip' will reduce the overall period of anaesthesia for the patient.

Pre-anaesthetic clipping has been advocated in some older textbooks, but it is now avoided because it has been shown to increase significantly the bacterial load on the skin, resulting in increased risk of SSI rates. Research has also shown that the longer an area of skin has been clipped, directly correlates with an increased rate of skin infection (Figure 1).⁶

Figure 1. Pre-anaesthetic clipping



Hair removal should be achieved using a set of well-maintained clippers and performed outside the theatre – usually in a prep room – to minimise the risk of hair particles contaminating the surgical field.

Whilst razors were once commonly used in veterinary practice, this is no longer considered an appropriate method owing to the significant risk of causing cuts and abrasions on the skin surface, leading in turn to the risk of wound infections resulting from the entry of resident and transient microorganisms found on the epidermis and hair shafts.

Provided that a set of *well-maintained clippers is used*, clipping is associated with the lowest incidence of surgical site infection. But be warned, if they are poorly maintained or used by inexperienced or careless staff members, unnecessary trauma to the skin will result with a consequent increased risk of surgical site infection as described above when using razors.

Bony prominences and areas where the skin is thin, for example the axilla, can be very susceptible to trauma, so extra care should be taken.

An area of 15-20cm around the proposed incision site (taking into consideration the potential need to extend the site as a consequence of complications) is recommended in order to prevent hair contamination. If patients have particularly long coats, it is advisable to clip the surrounding hair a little shorter to avoid contamination.

To achieve a close surgical clip, work against the direction of the hair. Open wounds should be protected from additional contamination from loose hair by covering the area with saline-moistened gauze swabs or applying a sterile water-soluble gel to the area.

Once clipping has been completed, the patient and the area need to be thoroughly vacuumed to remove any loose hairs – a 'sticky roll' can be useful to pick up any loose hairs prior to surgical skin preparation.

Surgical skin scrubs & preparations

A surgical skin preparation is performed to:

- reduce the transient and resident microbial counts at the surgical site immediately
- before making the surgical incision
- minimise 'rebound' microbial growth during the intra-operative and postoperative period
- reduce the risk of SSI

There is both a mechanical and a chemical element to skin preparation.

Mechanical

Mechanical friction, such as rubbing the skin with a sponge, is necessary to remove bacteria and enable antiseptic solutions to penetrate the deeper layers of the dermis where there are resident microorganisms. The use of friction in 'prepping' skin prior to a procedure is key to preventing infection.

Chemical

Involves the destruction of microorganisms and the prevention of 'rebound' microbial growth after scrubbing.

Commonly used scrub solutions include chlorhexidine, povidone-iodine and alcohol. It has been documented that cleaning the skin with chlorhexidine-

alcohol is superior to cleaning with povidone-iodine to prevent superficial skin infections and deep incisional infections.^{7 & 8}

The exception is when prepping for ophthalmic or aural surgery; because chlorhexidine is a corneal irritant and ototoxic, causing deafness following contact with the inner/middle ear. In these cases, povidone-iodine is the solution of choice.

A study to evaluate the use of different skin preparation techniques in veterinary practice found that 79 per cent of practices were unaware of the concentration of scrub preparation being used, or the contact time necessary between the antiseptic and skin during surgical preparation. In some cases, the concentration of antiseptic being used may have been too low to be effective!

Twelve per cent of practices used chlorhexidine gluconate and povidone-iodine together to prepare the skin; however, these two agents are incompatible and the combination, therefore, provides limited or no skin asepsis.⁹

Once the hair is clipped and the excess has been removed, the skin can be 'prepped'. Surgical skin preparation has two phases – initial and final.

Initial skin preparation

There are a number of important principles that should be followed during the initial phase of skin preparation:

- carried out in the prep room (never in the theatre)
- performed using a warm 50:50 water/4% chlorhexidine solution, this helps prevent excessive cooling of the patient
- if performing a limb prep, avoid clipping the foot (unless it's being operated on) and bandage the foot prior to prepping
- non-sterile gloves should be worn to prevent cross contamination (this is not a substitute for good hand washing!)
- *only* lint free swabs should be used as they do not leave fibres on the skin which could find their way into the surgical site, potentially transferring skin microbes with them and increasing the risk of an SSI



Figure 2. Final skin preparation

- scrub the surgical site area with a methodical back and forth motion for 30 seconds starting from the incision site and moving out towards the periphery. This should be repeated with a new swab for a minimum of four times or until the swab is clean after use and the required antiseptic contact time has been achieved
- avoid excessive pressure, as this may cause skin abrasions and increase bacterial load at the surgical site
- avoid using excessive water as this may dilute the scrub solution, reducing its efficacy and it may also increase cooling of the patient
- cover the prepped site with a sterile disposable drape if transfer to theatre requires movement of some distance.

Avoid spray bottles

Prolonged use of multi-use containers has resulted in contamination with *Pseudomonas aeruginosa*.

These microorganisms can survive for more than a year and can result in subsequent infections.¹⁰

Final skin preparation

Considerations during final skin preparation include:

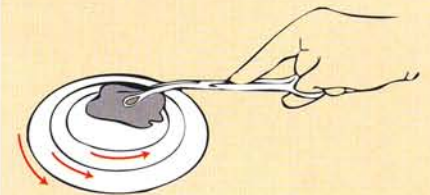
- procedure should be carried out in the operating theatre under completely sterile conditions (Figure 2)
- position the patient, before removing the sterile drape
- perform the final prep wearing sterile gloves or using sterile sponge-holding forceps or an applicator
- the surgical prep can be repeated with a fresh solution of a 50:50 water/4%

chlorhexidine solution, followed by an alcohol spray. An alternative would be to use the relatively new applicators which contain a specific measurement of 2% chlorhexidine gluconate and 70% isopropyl alcohol (ChloraPrep, Invicta) which has been proven to have significant antimicrobial activity, www.invictavet.com

- the surgical prep solution should not contain a detergent and should be from the same chemical family as the one used in the initial skin prep in order to prevent different agents inactivating each other.

Concentric pattern or not?

Historically, we have been taught to prepare the area starting from the incision site and working outwards in concentric circles until the outer margins are reached. However, this method does not have an evidence base.



Recent studies in the human field have shown that a back and forth scrub movement reduces microbial counts on the skin (McDonald Vox San, 2006).¹¹

The theory behind this is that following a circular pattern in the same direction may not allow penetration of the antiseptic solution into the cracks and fissures of the skin.

Prevention of hypothermia

During general anaesthesia, patients are unable to regulate their body temperature.¹² Keeping the patient warm during general anaesthesia provides many benefits, including a reduction in incidence of SSI.¹³

The veterinary nurse plays an important role in preventing heat loss and various methods can be implemented to slow heat loss down. These include the use of 'bubble wrap', warm IV fluids, using warm surgical scrub and minimal amounts of alcohol during the surgical prep, minimising the area of hair clipping, surrounding the patient with warm air by means of a Bair Hugger/ Hotdog, and warming the inspired air using heat exchangers and low flow rate re-breathing systems in appropriate patients.

The surgical environment should be kept warm and anaesthesia times kept as short as possible. All intravenous and lavage fluids should be used at body temperature.

Personnel dress and theatre conduct

Personal hygiene is a 'must' for all staff members that work in the theatre area. The most common mode of transmission of pathogens is via the hands and good hand hygiene is the most important factor in reducing nosocomial infections within hospitals.¹⁴ Daily showers and clean hair should be taken as a 'given'.

Figure 3. Facemask



Figure 4. Assisting in procedure

Fingernails should be short and forearms bare.¹⁴ All jewellery must be removed and staff should wear a clean pair of 'scrubs' every day, changing them immediately if they become contaminated. Theatre scrubs should be reserved for the theatre only to reduce transferring microorganisms into the operating room.

The use of surgical facemasks by the operating team has not been shown to prevent SSI in human or veterinary patients. Masks were introduced approximately a century ago to protect patients from surgical site infections based on the theory that wounds could become infected by bacteria in droplet form from hospital staff in the operating room.¹⁵

The use of masks was questioned in a study by Orr which demonstrated that operations carried out in theatres where hospital personal did not wear masks showed no increase in post-surgical infection rates compared to patients where staff wore masks.¹⁶ It is generally acknowledged that the evidence to support the continued use of masks is limited yet most guidelines for dress codes continue to recommend their use. In fact, several studies appear to show that there is a decrease in infection rates when masks are not worn.¹⁵

There is also a lack of research exploring the question of whether surgical masks should be used to protect hospital staff from contamination (Figure 3). It is also possible that the act of wearing a mask may help theatre staff to adopt an appropriate mind-set whilst in theatre,

enabling higher standards of asepsis to be maintained.

Surgical hats should be worn by all theatre personnel because hair collects bacteria when left uncovered. The use of head covers (and beard covers where necessary!) prevents these bacteria, dandruff and other contaminants from falling into the surgical environment. Shoe covers are not necessary for prevention of surgical site infection but staff should have suitable foot wear that is worn in the operating area only.

The operating team will be required to wear sterile gowns and gloves. Sterile gloves provide an additional barrier – but remember that 30 per cent of gloves have defects and so this is not an alternative to proper hand scrubbing (Figure 4).¹⁷

Surgical gowns and drapes should be sterile, resistant to liquid penetration and remain effective barriers – even when wet. Sterile surgical drapes should be used to create a barrier between the surgical field and the environment or any potential source of bacteria.

Unnecessary movement of staff in and out of the theatre should be avoided. In the human field it has been shown that significant theatre traffic increased the level of particles in the air. Additionally this movement can cause lapses in concentration that may potentially increase the chances of surgical mistakes being made.¹⁸

Research has also shown that bacteria from personnel on the peripheral field of



Figure 5. Surgical rubs

the operating theatre, with no physical contact with the patient, have been isolated within the surgical site.

Hand hygiene

Hand hygiene is one of the most important measures used to prevent hospital-acquired infections, but it is an area that requires standardisation within the practice setting. Hand washing protocols need to be available to every staff member and enforced at all times.

Hands should be washed:

- before patient contact
- before performing any aseptic task
- after contact with patients, bodily fluids and hospital environment.

We are all familiar with the surgical hand scrub procedure, but the introduction of newer hospital-grade hand rubs is encouraging a move away from the traditional methods of hand preparation towards hand rubs (Figure 5). These achieve surgical asepsis within a 1.5-minute application, whilst avoiding the abrasive action of brushes and excessive use of water, www.productcatalogue.bode-chemie.com/products/hands/sterillium.php

Equipment cleaning & sterilisation

It goes without saying that the operating room should be kept clean and access

allowed only to theatre staff. All equipment needs to be cleaned and sterilised as per the manufacturer's guidelines. Cleaning is a prerequisite to disinfection as it involves removal of organic material from the surface of the equipment. A hospital-grade disinfectant should be used and manufacturer's guidelines must be followed.

Cleaning of anaesthetic equipment should be included in the theatre SOP. *Pseudomonas aeruginosa* is a common opportunistic microbe which can be passed from patient to patient if anaesthetic equipment is not disinfected regularly.¹⁹

Sterilisation is the process of making an object free of bacteria and bacterial spores, as well as other microorganisms – usually by heat or chemical means. In the veterinary setting, this is normally achieved by using an autoclave which creates high temperatures and steam under pressure to kill microorganisms on equipment.

Other forms of sterilisation found in veterinary practices, include ethylene oxide (EO), which is a form of gas sterilisation and Sterrad sterilisation which uses hydrogen peroxide gas plasma technology to sterilise. It has far fewer health and safety considerations compared with EO and equipment can be used straight away.

Prior to sterilisation, equipment needs to be correctly packaged and labelled with

the contents and date of sterilisation. Surgical kits packaged in heat-sealed pouches remain sterile for up to one year if stored correctly. Storing sterilised equipment in closed cabinets will have a longer shelf life.

All sterilising equipment should be serviced and maintained. The use of self-contained biological indicators (SCBI) should be used at least annually to ensure adequate sterilisation is being achieved.

Tissue handling

Back in the 18th century, William Halsted 'The father of safe surgery' compiled the seven principles of surgery, which to this day are still used and assist in the prevention of SSI.

Halstead's seven principles of surgery:

- handle tissues gently
- control haemorrhage carefully
- preserve blood supply
- observe strict asepsis
- minimise tissue tension
- appose tissue accurately
- eliminate dead space.

Today we could add many others, such as:

- keep tissues moist, especially abdominal and thoracic organs
- make a skin incision large enough for the surgical procedure to be performed to prevent unnecessary tissue trauma
- take biopsies when needed, and always submit them to the lab
- provide adequate pain relief.

Prophylactic antibiotic use

Prophylactic antibiotic therapy in the perioperative period is used to reduce the incidence of postoperative wound infection, and to support the patient in situations where contamination might arise following surgical intervention.

In some incidences, these antibiotics may need to be continued after surgery depending on the surgical findings (leakage from the GI tract, for instance). It could be argued that the veterinary profession is still using inappropriate prophylaxis by the unnecessary administration of broad-spectrum agents

and continuation of therapy beyond the recommended time period; which increases the risk of adverse effects and promotes the emergence of resistant organisms.⁹

Data in the human field support the fact that an increasing number of resistant pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA) – are now a common finding in surgical sites; and although these data are not conclusive in our veterinary patients, we are seeing an increase in the reported cases of MRSA infection, particularly in orthopaedic procedures where surgical implants are used.⁹

This can be as a result of bacteria from the patient's own flora or from staff/owners involved in the patient's care. There is good evidence to suggest that inappropriate use of perioperative antibiotics may increase the risk of surgical site infection by opportunistic organisms that are increasingly difficult to eradicate.⁹

The following situations would warrant prophylactic antibiotic therapy:

- surgery time longer than 90 minutes
- prosthesis implantation
- patients with pre-existing prosthesis
- severely infected or traumatised wounds.

Prophylactic antibiotic therapy can be reduced if the surgeon follows Halstead's surgical guidelines. We know that the patient is by far the biggest risk factor in the development of bacterial contamination, which highlights the importance of good patient preparation as discussed earlier and the need for the surgeon, surgical environment and equipment to be prepared correctly.

A recent survey of first opinion practices demonstrated that the veterinary industry still has some way to go in achieving the standards needed to achieve surgical asepsis – with only 37.5 per cent of staff wearing sterile surgical gloves during surgical procedures, and gowns, masks and facemasks being worn in just 14.3, 12.5 and 10.7 per cent of practices, respectively.⁹

Before administering prophylactic antibiotics, the veterinary surgeon must weigh up the likelihood of the wound encountering contamination during the

surgery, or whether there is an increased risk of infection if contamination were to occur, such as during orthopaedic procedures. In these instances, the use of prophylactic antibiotics may be justified. *Antibiotic therapy should never be used as a substitute for poor aseptic techniques.*

The following is a standard protocol for the use of prophylactic antibiotics in surgery:

- intravenous broad spectrum antibiotic administration e.g. cefuroxime or amoxicillin/clavulanate at a dose rate of 20mg/kg
- 30 to 60 minutes before the first incision
- repeated every two hours, depending on length of surgery; and discontinued immediately after wound closure or within 24 hours.

Postoperative care

Once the patient leaves theatre, the maintenance of asepsis must continue, with constant wound and environmental management. Wounds should be covered with a sterile dressing before the patient leaves theatre and this should be changed as soon as it becomes soiled or contaminated by 'strike-through'.

Kennels must be cleaned to a high standard and clean dry bedding provided. Vetbeds are ideal in situations where the patient may be recumbent as they 'wick' bodily fluids away from the patient.

Monitoring infection control measures

To ensure that preventive methods are working to reduce the incidence of SSI, it is important that the practice carries out a clinical audit. The aim of an audit is to highlight any sudden increase in complications enabling you to assess procedures in place and make adjustments as necessary.

The NHS has a surgical site infection prevention and treatment of surgical site infection clinical audit template (NICE clinical guideline 74) that can be accessed on line and could be easily adapted for veterinary practice use.

Conclusion

Total eradication of SSI is unrealistic because contamination can occur from the patient, surgical team, surgical

and hospital environment. With high standards of infection control in place throughout all areas of the practice, however, our aim should be to try and limit contamination.

Even the smallest veterinary practice can make significant changes in their patient and environmental management to reduce the incidence of SSI. [vni](#)

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