Surgical Site Infections: Can We Reduce Their Occurrence?

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Introduction

Despite modern advances in surgical technique and the use of perioperative antimicrobial prophylaxis, surgical site infections (SSIs) remain a frustrating complication in small animal surgery. In fact, the incidence of SSIs may be on the rise as more advanced procedures are being performed in older patients. It is not practical to think that SSIs can be completely eliminated; however, important strategies for identification of high-risk patients and prevention exist in order to reduce their impact. Of further challenge in the prevention and treatment of SSIs in veterinary medicine is the rise of multidrug resistant bacteria that are difficult to treat and may have important zoonotic consequences.

Definition of a Surgical Site Infection

It is important to standardize definitions of SSIs to allow for objective identification and future comparative evaluations. Table 1 summarizes The United States Centers for Disease Control (CDC) and Prevention classification system. In addition to this system for subjective diagnosis of SSIs it is recommended that a wound sample be obtained in all cases for bacterial culture and sensitivity to guide antimicrobial treatment. This system categorizes infections into incisional versus organ space and further classifies incisional infections into superficial and deep.

Table 1: SSI Definitions

Category	Criteria
Superficial SSI	Within 30d Skin and/or subcutaneous tissues 1 or more of: ▪ Pus ▪ Bacteria ▪ Diagnosis by a surgeon Heat, redness, pain OR localized swelling AND incision reopened by surgeon UNLESS culture negative
Deep SSI	Within 30d, 90 days with implant Deep soft tissues of the incision 1 or more of: ▪ Pus ▪ Spontaneous dehiscence of deeper incision OR incision is deliberately opened when patient has fever, localized pain OR tenderness UNLESS culture negative Abscess or other evidence of infection on imaging or histology
Organ/Space SSI	Within 30d, 90 days with implant Any area other than the incision that was encountered during surgery 1 or more of ▪ Pus

- Bacteria
- Abscess or other evidence of infection on exam, re-operation, histology or imaging

Incidence

Nosocomial or healthcare-associated infections pose a tremendous challenge in veterinary and human medicine. SSIs are one of the leading causes of nosocomial infections in humans and account for ~40% of these infections in surgical patients. Similar scrutiny and quantification of SSIs have not been performed in small animal surgery, however, various studies have provided SSI rates of 0.8-18% of surgical procedures. A recent study at the Ontario Veterinary College Health Sciences Center (OVCHSC) which enrolled ~1000 consecutive dogs or cats undergoing surgery revealed an overall SSI rate of 2.9%. Orthopedic surgical procedures had a significantly higher rate of SSIs compared with soft tissue and neurologic procedures.

Impact

SSIs can have a significant impact for the patient, pet owner, and veterinary care-givers including prolonged hospitalization, increased treatment costs, additional surgery, poor cosmesis, risk of drug side effects and patient death. Additional important consequences include, pet owner frustration and grief, veterinary care-giver frustration and grief, negative public perception and potential liability. Fortunately, SSIs are a rare complication. However, their economic and emotional impact for the pet owner and veterinarian should not be overlooked. Nicoll and colleagues recently reported the economic impact of TPLO SSI. Postoperative treatment costs associated with TPLO SSI ranged from CAD $145 to $5022 and dogs with SSI returned for a mean of 4.1 (range 1–13) postoperative visits for additional evaluation related to SSI. The mean duration of final case closure from the day of surgery was significantly longer in SSI dogs (194 days) compared with control dogs (71 days). The investigators concluded that the costs for TPLO SSI are often tremendous, emphasizing the need for a thorough, multimodal SSI prevention program.

Biofilm-Theory of Infection

It has been well described that bacteria prefer a community-based lifestyle as this provides a survival advantage compared to a nomadic existence. Bacterial biofilms are defined as a community of bacterial cells enclosed within a self-produced polymeric matrix (predominantly carbohydrates) adherent to a living or non-living surface. Within a biofilm, bacteria are protected from the host immune response and antimicrobials. Furthermore, bacteria embedded within a biofilm undergo a lifestyle change and reduce their metabolism and growth rates, which provides an additional survival advantage as many antimicrobials target actively growing bacteria. It has been shown that biofilm bacteria can be up to 1000x more resistant to antimicrobials compared with their free-living counterparts.

We now assume that chronic and implant-related infections are the result of biofilms. Further evaluation of the biofilm-forming ability of common pathogens found in veterinary medicine is required in order to optimize treatment and prevention strategies.

Risk Factors for SSI

Each time a surgeon creates a wound, it will become contaminated with bacteria. However, only a small number of incisions will turn into SSIs. Several risk factors have been identified in veterinary patients for development of SSIs:

- Degree of bacterial contamination in the wound (Table 2)
- Clipping of surgical site prior to induction of anesthesia
- Duration of surgery – risk doubles for every hour of surgery time
- Duration of anesthesia – 30% greater risk for each additional hour
- Propofol
- Presence of an endocrinopathy (particularly diabetes mellitus)
- Number of people in operating room – 30% greater risk for each additional person
- Tibial plateau leveling osteotomy
- Orthopedic surgery

Table 2 – National Research Council risk index for SSI

Strategies for SSI Prevention

Class	Description
Clean	Non-traumatic, uninfected No break in aseptic technique No inflammation encountered Elective, primarily closed, no drains
Clean-Contaminated	Controlled entry into hollow viscus Minor break in aseptic technique
Contaminated	Open, fresh traumatic wound Incision into a site with acute, nonpurulent inflammation Major break in aseptic technique
Dirty	Pus encountered Perforated viscus Traumatic wound with devitalized material

Preventive strategies should be based on reducing the risk and improving the ability of the patient to eliminate bacterial contamination. The strategies discussed have been adopted from human surgical practice as these measures have not yet been validated in veterinary medicine.

Preoperative Strategies

These strategies focus on managing patient risk factors, patient preparation and appropriate presurgical hand asepsis of the surgical team. Patient factors (e.g. distant infections, treatment of endocrinopathy, obesity) should be addressed prior to surgery for elective procedures. Preparation of the patient and surgical site is an important consideration as this should reduce potential opportunistic pathogens while not creating an environment that will enhance or favor SSIs. Presurgical hand asepsis of the surgical team is a long-standing practice. Recently, the use of alcohol-based rubs has been shown to be more effective than scrubbing techniques. Antimicrobial prophylaxis is an important and controversial subject. Prophylaxis in clean-contaminated, contaminated and dirty procedures is indicated, however, use in clean procedures requires further study. The goal of prophylaxis is to reduce intraoperative contamination to a level where the patient's defenses can easily remove bacterial burden. Selection of antimicrobials for prophylaxis should be based on the most common pathogens likely to be encountered and should be administered prior to incision so that bactericidal concentrations in the serum and tissues are present.

Perioperative Strategies

As surgical time has been shown to be a risk factor for SSI in veterinary medicine, efficiency is an important consideration. Also, adherence to Halsted's principles (gentle handling of tissue, strict aseptic technique, sharp dissection of tissues, appropriate hemostasis, removal of devitalized tissue and foreign bodies, obliteration of dead space and avoiding tension) is a requirement when performing any surgical procedure. The use of caps, masks, gloves, and gowns by all members of the surgical team should be used to minimize contamination of the surgical wound.

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Postoperative Strategies

An SSI can occur up to 30 days after a surgical procedure and the risk remains for as long as years if an implant (e.g. bone plate or total hip prosthesis) was placed. The incision should be protected from contamination by the patient's own flora, the hands of medical caregivers or the environment for a minimum of 24-48 hours. Appropriate hand hygiene when handling the surgical site is of great importance as it has been shown that hands of medical caregivers are a leading cause of SSIs in human hospitals. Pet owners must be made aware and counseled on signs of SSIs. Prompt evaluation by a veterinarian should be encouraged if concerns about incisional health or integrity arise. Post-operative continuation of antimicrobial prophylaxis should be discontinued as this practice could lead to an increased risk of SSIs.

Surveillance

In human surgical practice it has been shown that surveillance of SSIs and reporting this data back to surgeons is an important measure in reducing the risk of SSIs. A study of human orthopedic patients by Houtari and Lyytikainen[17] reported that 384 SSIs were detected following with 215 being detected after discharge from the hospital. 215 SSIs were detected following discharge with 93 detected on readmission, 73 detected based on postdischarge questionnaire alone, and 23 detected on a follow-up visit. This study illustrates the necessity for rigorous postdischarge surveillance and the significant impact surveillance has on the number of SSIs detected after orthopedic surgery. The exact mechanism by which this reduction in SSIs rate occurs is not completely understood, however, it has been speculated that the Hawthorne effect (improvements in technique by subjects when they know they are being watched) plays an important role. SSI monitoring requires active, patient-based, prospective surveillance. Post-discharge and ante-discharge surveillance methods should be used to detect SSIs following inpatient surgeries and post-discharge surveillance for outpatient operative procedures. Methods for surveillance of human surgeries as per the CDC are summarized in Table 3.[18]

Table 3: Methods for active, patient-based, prospective surveillance.

Review of medical records or surgery clinic patient records admission, readmission, emergency department, and operating room logs
Patient charts for signs and symptoms of SSI
Lab, X-ray, other diagnostic test reports
Nurses and physician notes
Visit the ICU and wards – talk to primary care staff
Surgeon surveys by mail or telephone
Patient surveys by mail or telephone

The implementation of SSI surveillance in veterinary medicine is gaining traction and it is recommended that practitioners initiate a post-discharge procedure specific surveillance program to document baseline SSI rates. In a recent veterinary study by Turk et al, active postdischarge surveillance detected 9 SSIs (34%) that would have gone undetected without postdischarge surveillance.[19] Stickney and Mankin (2017) reported that 27.8% of postdischarge SSIs (orthopedic, soft tissue and neurologic surgery) would not have been detected without active intentional surveillance.[20] With this data, the early stages of an outbreak can be identified and appropriate measures taken to prevent further development.

Novel Approaches

Although systemic antibiotics are considered standard of care for both SSI prophylaxis and treatment, a number of factors may compromise efficacy. These include antibiotic penetration to provide adequate concentrations for sufficient time at the surgical site, acquisition of antibiotic resistance traits by the infective organism, administration compliance, and dose-limiting antibiotic toxicity profiles. In response to these issues, there has been increasing interest in products providing local antibiotic therapy. There are several purported advantages of local antibiotic use, both for treatment and prophylaxis. High local antibiotic concentrations can be achieved at the surgical site, improving penetration of biofilm and necrotic tissue and increasing bacterial kill for antibiotics with concentration-dependent kill characteristics. [21] Hayes et al (2013) reviewed the use of antibiotic-impregnated cement, gentamicin-impregnated collagen sponges, antibiotic-impregnated gels, antibiotic-impregnated demineralized bone matrix and the antibacterial properties and coatings for surgical implants in veterinary orthopedic surgery.[21]

Turk et al investigated the enzyme DispersinB in-vitro, and found that while it did not have any effect on MRSP growth, it reduced biofilm formation and degraded established biofilm. This research establishes that an in vivo investigation of DispersinB as treatment option for MRSP biofilm-associated infections in our veterinary orthopedic patients is warranted.[22] Investigation of elution of this enzyme from a local delivery vehicle is currently underway at the Ontario Veterinary College.

It has been established that one of the most critical pathogenic events in the development of implant-associated infection is biofilm formation that starts immediately after bacterial adhesion on an implant and effectively protects the microorganisms from the immune system and systemic antibiotics. A focus on inhibition of both bacterial adhesion and biofilm formation when implanting devices should result in lower SSI rates. Implementation of this concept can be as simple as use of triclosan-coated suture material. In fact, CDC guidelines now include a recommendation that health care professionals should consider the use of triclosan-coated sutures for the prevention of SSI.

Conclusions

SSIs are substantial cause of morbidity for our patients and lead to increased complication rates and increase treatment costs for pet owners. With the rapid emergence of multi-drug resistant bacteria, SSIs will continue to be a challenge to treat. Strict adherence to preventive strategies and appropriate SSI surveillance will help reduce the risk of SSIs.

Suggested Reading

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