

Old and New Thoughts on Infection Control in Small Animals

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The most common pathogen involved in small animal surgical site infections today is *Staphylococcus pseudintermedius*. The overall carrier rate of this methicillin-resistant pathogen is approximately 4.4%, with a 14 times higher infection rate in part due to its ability to develop a biofilm. This pathogen and others are found in the normal commensal organisms of the canine skin appendages. Typical skin infection rates for most elective surgical procedures run approximately 3 - 5%, though are much higher in TPLO surgeries, reported up to 21 - 28%, becoming a more difficult problem to combat.

Surgical site infections (SSI's) are defined by the Center for Disease Control as; superficial incisional (less than 30 days), deep incisional (30 days to 12 months), or organ space (30 days to 12 months). Surgical wounds are classified as clean, clean-contaminated, contaminated and dirty, and preventable or non-preventable. Acute SSI's may arise from other comorbid infections prior to the procedure such as urinary tract infections or pyoderma. Chronic infections may result from the hematogenous spread from other distant areas such as dental disease or endocarditis. There is concern that reported infection rates are not accurate as many may be treated by doctors not involved in the initial treatment of the patient, or the incident may not be reported in the record accurately.

Many causes of increased susceptibility to SSI's are cited in the literature. An $\text{SaO}_2 < 90\%$, or a blood pressure less than 60 increase the risk of SSI by 27 times. Use of propofol as an induction agent increases the susceptibility to infection by 38%. Prolonged anesthetic times, increased number of people in the operating room, and clipping the hair longer than 4 hours before surgery may also make patients more susceptible to SSI's. In TPLO surgery, use of non-locking plates may lead to increased instability of the osteotomy site and necrosis around the screw-holes, leading to potential SSI, though a more recent study refutes this idea. Use of skin staples increases the chances of infection from approximately 3 to 5%, while the use of triclosan-impregnated sutures may decrease SSI.

Methicillin-resistant *Staphylococcus pseudintermedius*, or MRSP is defined as a bacterium that has developed resistance to beta-lactam antibiotics through natural selection or gene transfer. Many of these organisms develop their resistance to antibiotics through the development of a biofilm which protects them from the immune system or the medication. Beta-lactam antibiotics are a class of drug consisting of all antibiotic agents that contain a beta-lactam ring in their molecular structures. This includes penicillin derivatives (penams), cephalosporins (cephems), monobactams, carbapenems and carbacephems. Penams include penicillin G, amoxicillin, cephalosporin C, cefoxitin, thienamycin, aztreonam, and clavulanic acid.

Hospital acquired infections occur most commonly during the placement of medical devices such as bone plates, intramedullary pins, IV or urinary catheters. Long procedure times, or underdeveloped skill may contribute to increased infection rates. Clothing worn by hospital staff cultured MRSP 14% and Methicillin Resistant *Staphylococcus aureus* (MRSA) 3.5%. Commonly identified sources of infection included the patient gurney, the radiology table, and the staffs' hands that handled the patient after surgery.

Deterrence methods of SSI's are cited in the literature. Use of triclosan-impregnated suture and intradermal closures might be a better choice of skin staples. Iodine impregnated sheets applied to the patient during surgery and use of impervious barriers decrease chances

of SSI's. Double-gloving or using orthopedic surgery gloves minimize the chances of glove puncture during a procedure, although gloves should still be changed after draping the patient, and after 60 minutes of surgery. Application of an antimicrobial cream and a light bandage before leaving the operating table is a suggested practice to minimize wound contamination while still in the hospital.

Proper patient selection is important to minimize the chance of an SSI. Older patients in poor health, or obese intact males incurred higher SSI's in one study. Patients with concurrent comorbidities may likely increase the odds of acquiring an SSI. The use of orthopedic implants dramatically increases the opportunity for the formation of an SSI and a biofilm, making infection resolution difficult. Knowing the potential epidemiology of the offending bacteria prior to surgery and pre-planning antimicrobial prophylaxis plan is becoming increasingly difficult as resistant rates increase to current antibiotics in use.

The Center for Disease Control currently recommends that antimicrobial prophylaxis (AMP) in human medicine be discontinued 24 hours after surgery. AMP continues to be a great area of debate in veterinary medicine as there are currently no standardized guidelines. Most proposed protocols include usage of various dosages of cephalexin, with most SSI's involving organisms that are resistant to that drug. Other methods of prevention such as frequent hand washing, wearing gloves when handling patients, and keeping the wounds covered at least until discharge from the hospital should preclude inappropriate use of AMP. The literature does seem to agree that some sort of AMP is appropriate when performing orthopedic procedures involving bone plate implants.

Surgeon preparation should begin with appropriate clothing, surgical scrubs, hat, mask, sterile gown impervious surgical gown and a 3-minute scrub of the hands with an appropriate purpose-based and dedicated hand scrub, preferably one that is foot-activated to minimize contamination. Hand rubs, chlorhexidine and alcohol-based, are becoming more popular and are equally as effective as traditional soap-based scrubs. Scrub brushes are no longer recommended by the World Health organization as they may cause excessive abrasions of the hands. Double gloving is recommended for orthopedic procedures, and gloves should be changed for procedures lasting longer than 60 minutes as the chances of a puncture increase at that point.

Successful prevention of SSI's includes appropriate sterilization of all surgical equipment utilized in the veterinary practice. Most practices use steam sterilization, the gold standard. Autoclaves should be maintained on an annual basis to check for seal leaks, intensive cleaning, and verifying the unit reaches appropriate temperature and pressure to provide an adequate sterilization environment. Sterilization tape applied to the outside of the pack is temperature dependent and only tells you that the temperature of 121°C was reached, it says nothing about the time exposure. Indicators placed deep inside the surgical pack are also recommended following the guidelines of the Bowie-Dick Test using commercially available products from sterilization suppliers.

Many newer instruments utilized in veterinary medicine and surgery have plastic components to them, in some instances allowing for them to be cleaned and reused in certain procedures such as endoscopy cameras, laparoscopy cannulas and orthopedic drill batteries. These instruments are not steam autoclavable, necessitating alternative methods of sterilization. Ethylene oxide (ETO or ozone) autoclaves have been available to veterinarians for years, but concerns of environmental contamination, carcinogenetic potential, and volatility have increased concerns of use. Further, one load in an autoclave is about double the cost of a steam sterilization load, and each ETO load must be allowed to air-free of gas for a 24-hour period.

Hydrogen peroxide plasma sterilization was first patented in the late 1980's. According to the manufacturer, the sterilization chamber is evacuated, and hydrogen peroxide solution is injected from a cassette and is vaporized in the sterilization chamber to a concentration of 6 mg/l. The hydrogen peroxide vapor diffuses through the chamber, exposes all surfaces of the load to the sterilant, and initiates the inactivation of microorganisms. An electrical field created by a radio frequency is applied to the chamber to create a gas plasma. Microbicidal free radicals (e.g. hydroxyl and hydroperoxyl) are generated in the plasma. The excess gas is removed and in the final stage (i.e. vent) of the process the sterilization chamber is returned to atmospheric pressure by introduction of high efficiency filtered air. The by-products of

the cycle (e.g. water vapor, oxygen) are nontoxic and eliminate the need for aeration. Thus, the sterilized materials can be handled safely, either for immediate use or storage. The process operates in the range of 30°C and has a cycle time of 7 - 36 minutes. If any moisture is present on the equipment, the vacuum will not be achieved and the cycle aborts. Plasma sterilization lends the opportunity to extend the life of expensive, sensitive veterinary equipment. Plasma sterilization is intended to supplement steam sterilization and not replace it.

Cold atmospheric plasma, or ionized gas at low temperature and atmospheric pressure, is an emerging decontamination method with a wide variety of potential applications. Cold plasma generated in air produces ultraviolet light, charged particles, and reactive oxygen and nitrogen species (RONS)-all of which cause rapid destruction of microorganisms while having limited negative effects on sensitive background substrates. Veterinary instrument sterilization by cold plasma treatment has been investigated for over two decades but its practical applications for easy use have been limited. Fortunately, cold plasma can be generated in many different ways and the limitations imposed by the complex apparatuses of previous cold plasma sterilization devices can be overcome.

Plasma Bionics, LLC has developed a plasma-based sterilization device in an innovative and convenient form factor that can be used for sterilizing veterinary instruments of a wide range of sizes and materials. By utilizing one of the simplest plasma generation methods, surface dielectric barrier discharge (SDBD), plasma is generated with air at room temperature and atmospheric pressure, requiring no additional enclosures or supplied gas flow. SDBD produces plasma as a result of charge accumulation on one side of a dielectric barrier placed between two electrodes. The electric potential accumulates to a point until the air between the electrodes is ionized, forming plasma.

One of the results of the SDBD process is the production of an induced localized airflow. Accordingly, SDBD has been extensively researched and developed for applications in the aerospace industry, in which it is used to induce or modify airflow over the surfaces of aircraft wings. It is a low-power, active flow control technique used to improve the aerodynamic characteristics and propulsion efficiency of aircraft. When used for sterilization applications, the induced airflow allows delivery of RONS, and particularly ozone and nitrogen dioxide (both FDA approved sterilant compounds), to surfaces that are at a distance from SDBD actuators themselves. When applied within an airtight enclosure, RONS accumulate to high levels and contact even the hardest to reach instrument crevices, allowing efficient sterilization with just air and electricity.

All surgical sites should be covered with 4 towels and a properly fenestrated, disposable drape. Footwraps during orthopedic procedures should be covered with impervious barriers to prevent microorganisms from seeping through to the surgical site. Use of iodine-impregnated sheets that stick to the surgical site may also be of benefit in preventing SSI but getting them to stick appropriately to the patient is considered difficult to some. Operative areas should be lavaged with normal saline prior to closure to decrease potential bacterial load. If the abdomen has been entered, it should be lavaged until the solution returns a clear or slightly pink color. Appropriate volumes have not been determined, though some feel that more vigorous attempts with larger volumes may actually worsen or spread peritonitis. A new lavage solution from Simini™ is showing great promise with superiority to chlorhexidine, iodine, and saline at minimizing bacterial load as well as biofilm formation in lavaged wounds. The author is currently using this product routinely for a post-TPLO surgical lavage with excellent results in minimizing postoperative infections. After the surgical site is closed, coverage of the surgical site with an appropriate antimicrobial ointment and a protective bandage is recommended before the patient leaves the operating room to minimize contamination of the wound while in the hospital environment.

Once a patient has been diagnosed with an SSI, a culture from the wound or implant, not the draining tract, is imperative in directing appropriate antimicrobial treatment. The implant should be removed at the earliest convenience and treated as potentially zoonotic until results are obtained. Collagen sponges can be saturated with gentamicin or amikacin and placed in the surgical site and have reported good results in the literature. Some patients show significant improvement and resolution with removal of the implant, curettage of the surgical site, and no other therapy.

In conclusion, 100% prevention of SSI's in veterinary surgery is not a realistic goal. Surgical and AMP protocols are not yet standardized, and that too may not be an expectation in our profession. At least in the case of TPLO surgery, the most commonly performed surgery with a high SSI, other steps in the procedure should preclude use of AMP as many of the infections occur weeks to months after the procedure, thus AMP is of little benefit. The best course of action is to pursue preventative measures as discussed in this article, and institute surveillance and monitoring programs in your hospital to minimize SSI's in your patients. With recent world events involving COVID-19 and a lack of personal protective equipment (PPE) for surgical procedures, it is more imperative than ever to assure surgical sterility as PPE shortages will most certainly impact the medical community.

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