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Surgical, Traumatic, and Bite Wound Infections

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Surgical and Traumatic Wound Infections

Etiology/Pathophysiology

In its most basic form, a wound is a break in the protective barrier organ that is the skin. Wounds can be created by almost anything, but are usefully described or defined in ways that reflect their degree of bacterial contamination, cause (i.e., bite wound, surgical site infection), and the depth or degree of tissue damage that accompanies them (i.e., superficial vs deep).

All wounds, regardless of cause or conditions present at their creation, can become infected. The likelihood of wound infection is directly related to the number and pathogenicity of bacterial contamination of the wound and inversely related to the overall health of the patient and the wound environment. This relationship can be defined as:

$$\text{Infection risk} = \frac{\#\,\text{of bacteria} \times \text{virulence}}{\text{Host resistance}}$$

A threshold number of 10^5 bacteria per gram of tissue has often been quoted for the establishment of infection in a wound. The relationship of contamination to infection is borne out by the significant relationship between wound classification as clean, clean-contaminated, contaminated, and dirty (a proxy for the level of bacterial contamination in wounds) and infection risk in small animals. This number, however, is not absolute, as a wound may become infected after contamination with fewer organisms if the host cannot respond appropriately to bacterial contamination (discussed later) or if the bacteria in the wound possess specific virulence factors. For example, *Staphylococcus aureus* bacteria that do not express compounds anchored to their cell walls that adhere to matrix molecules in the host tissue do not cause invasive infection.

The health of the host and local wound environment are also very important in determining resistance to infection. Although a number of systemic conditions are associated with risk of surgical infection in humans, few of these risks have been investigated in veterinary patients. However, it is likely that patients with significant co-morbidities or extremes of age may be more susceptible. The use of perioperative antibiotics can be viewed as a means of increasing host resistance to infection. Finally, intraoperative management of the patient, including surgical time, surgical technique, use of surgical implants, anesthesia time, and maintenance of normothermia, plays a role in host resistance to infection.

Epidemiology

The bacterial flora of a wound is initially determined by its location (i.e., perineal) and cause (i.e., bite wound), but as time passes, opportunistic nosocomial pathogens such as *Pseudomonas aeruginosa* and *Enterococcus* species become more prevalent. These bacteria often have inherent (*Enterococcus*) and acquired resistance to multiple classes of commonly used antibiotics.

In acute, nonbite wounds, bacterial culture and sensitivity are unlikely to be helpful, as bacteria isolated will reflect wound contamination that may or may not lead to infection. In this circumstance, empiric, broad-spectrum antibiotic treatment based on common flora of the skin is an appropriate first-line therapy. This should take into account the potential for bacterial resistance associated with previous antimicrobial therapy, in which case culture may be warranted.

The presence of biofilms is increasingly recognized as a factor in the pathogenesis of chronic wounds and surgical site infections associated with foreign materials or implants.

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Biofilms are multispecies aggregates of microbes that manufacture a protective carbohydrate matrix. Within this matrix, they are shielded from their environment, including the immune system and antibiotic therapy. Moreover, bacteria within biofilms assume a sessile rather than planktonic state, which diminishes the likelihood that they will be detected using conventional culture techniques.

Antimicrobial resistance is a growing problem in veterinary and human medicine and is seen in both nosocomial and community-acquired infections. Mechanisms of antimicrobial drug resistance have been well reviewed, and prevention and management of resistant bacterial infections are discussed in Chapter 114.

Signalment

Any animal can develop a surgical site infection or sustain a traumatic wound that becomes infected.

History and Clinical Signs

Surgical site infection is more likely to occur after contaminated surgeries or surgery on contaminated areas (e.g., perineal region), surgeries that involve the implantation of foreign material (orthopedic implants, mesh, bone allografts), and those that involve prolonged anesthesia time. However, any patient undergoing surgery is at risk of surgical site infection. Traumatic wounds that involve significant tissue trauma, that do not receive appropriate early treatment, that are penetrating in nature, or that leave embedded foreign material behind (e.g., pieces of bark) are more likely than superficial lacerations to become infected.

Wound infection is suspected based on the presence of redness, pain, exudate, or swelling of the wound area. In some cases, wound infection is characterized by an apparent delay or interruption of normal healing. Wound infections from surgical or traumatic causes can also be systemically apparent, causing fever, pain, tachycardia, and other signs associated with bacteremia or systemic inflammatory response. Sometimes systemic signs are more prominent than the superficial appearance of the inciting wound, highlighting the need for exploration and debridement of wounds.

Although it seems that wound infection should occur shortly following creation of the wound, it may take days or weeks (even months, in the case of wounds in which implants are placed) before signs of infection become evident. In addition, wound and surgical site infections can occur at various tissue levels, ranging from superficial or incisional infection to deeper or cavitary infection. The depth of infection can play a role in determining the most appropriate course of treatment.

Diagnosis

Box 112.1 defines criteria used in the diagnosis of surgical site infections. Though this scheme was designed to

Box 112.1 Criteria for surgical site infection (SSI) definition

Superficial incisional SSI

Infection occurs within 30 days after operation

and

infection involves only skin or subcutaneous tissue of the incision

and at least one of the following.

1) Purulent drainage, with or without laboratory conformation, from the superficial incision
2) Organisms isolated from an aseptically obtained culture of fluid or tissue from the superficial incision
3) At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness, or heat *and* superficial incision is deliberately opened by surgeon, *unless* incision is culture negative
4) Diagnosis of superficial incisional SSI by the surgeon or attending clinician

Suture abscess (minimal inflammation and discharge confined to points of suture penetration) is *not* considered a SSI.

Deep incisional SSI

Infection occurs within 30 days after operation if no implant is left in place or within one year if implant is left in place and infection appears to be related to the operation

and

infection involves deep soft tissues (e.g., fascial and muscle layers) of the incision

and at least one of the following.

1) Purulent drainage from the deep incision but not from the organ/space component of the surgical site
2) A deep incision spontaneously dehisces or is deliberately left open by a surgeon when the patient has at least one of the following signs or symptoms: fever, localized pain, or tenderness, unless site is culture negative
3) An abscess or other evidence of infection involving the deep incision is found on direct examination, during reoperation, or by histopathologic or radiographic examination
4) Diagnosis of a deep incisional SSI by a surgeon or attending clinician

Infections that involve both superficial and deep incision sites *and* organ/space SSI that drain through the incision are reported as deep incisional SSI.

Organ/space SSI

Infection occurs within 30 days after the operation if no implant is left in place or within one year if implant is left in place and the infection appears to be related to the operation

and

infection involves any part of the anatomy (e.g., organs or spaces), other than the incision, which was opened or manipulated during an operation

and at least one of the following.

1) Purulent drainage from a drain that is placed through a stab wound into the organ/space
2) Organisms isolated from an aseptically obtained culture of fluid or tissue in the organ/space
3) An abscess or other evidence of infection involving the organ/space that is found on direct examination, during reoperation, or by histopathologic or radiologic examination
4) Diagnosis of an organ/space SSI by a surgeon or attending clinician

Source: Modified from Horan *et al*. (1992).

assist the diagnosis of surgical site infection, it is applicable to the diagnosis of any wound infection.

When an infection is present, clinical signs, particularly pain, lethargy, local swelling, drainage (ranging from serous to purulent to sanguineous in gross appearance), are generally present. Draining tracts can occur in cases of deep traumatic or surgical site infection, particularly if devitalized tissue (e.g., bone sequestrum) or foreign material (e.g., plant material, retained gauze sponge, surgical implant) are present. Draining tracts may occur relatively distant to the inciting foreign material, depending on tissue planes.

A patient suspected of having an infected wound should be thoroughly evaluated with a physical examination and by imaging appropriate to the area of interest if the wound is believed to involve tissue deeper than the skin and subcutis. Patients with traumatic wounds to the trunk should be evaluated with thoracic and abdominal radiographs to evaluate for pneumothorax or pneumoperitoneum, and abdominal or thoracic effusion.

Though many patients with chronic or superficial infections are relatively unaffected, those with significant or deep injuries, uncontrolled infections, continued bacterial contamination, devitalized tissue, and/or abscess formation can show significant systemic illness. Evaluation of these patients should include, in addition to those diagnostics listed earlier, evaluation of a complete blood count, biochemical profile, and urinalysis. Blood and urine cultures may be submitted. Exploration and debridement of infected areas should be performed shortly after initial treatment for sepsis and shock (described elsewhere in this text).

Therapy

Superficial infections that involve only cellulitis without evidence of deeper extension or abscess formation may be managed with oral antibiotic therapy alone. However, antibiotic therapy is not a replacement for exploration and debridement.

Wound management commences after managing more life-threatening concerns, critical diagnostics, and instituting necessary fluid replacement, analgesia, and supportive care. To prevent cross-contamination of the wound and hospital environment, the wound should be covered with a clean dressing and personnel handling the patient and/or wound should wear examination gloves at all times.

Wound Preparation

Under appropriate general anesthesia or heavy sedation, the wounds are packed with damp gauze or clean water-soluble lubricant to prevent further contamination. Hair is clipped widely around the wound area. The most obvious wound openings may represent the “tip of the iceberg,” particularly when dealing with deep surgical site infections or bite wounds, so skin must be prepared to allow for extensive exploration and, if indicated, drain placement. Following hair removal, the wound and surrounding tissues are cleaned with an appropriate antiseptic detergent, such as chlorhexidine gluconate.

Exploration and Initial Debridement

The wound should be opened to its full extent to allow for complete exploration. Probing a smaller wound is not sufficient to determine its extent or level of contamination. The wound should be thoroughly assessed for involvement of deeper tissues or cavities (i.e., extension into the abdomen or thorax), necrotic or devitalized tissue, and foreign material. Necrotic, extensively contaminated, or devitalized tissue is judiciously removed using sharp dissection. Because many infected wounds are left open during initial treatment, serial debridement over several days is appropriate for important tissues of uncertain viability, which in some cases can partially or completely recover.

Lavage

Normal saline, a buffered isotonic fluid (i.e., lactated Ringer's solution [LRS]), or, in the case of significantly contaminated or large wounds, clean tap water can be used to copiously lavage the area. Though the hypotonicity of tap water is theoretically cytotoxic to cells in the wound, the clinical effect of this is not significant and may be outweighed by the practical utility of using a large sprayer or shower head to remove gross debris from a large wound area. The use of tap water lavage has not been shown to increase wound infection rates compared to saline in several human studies. Some authors promote intermediate pressure irrigation of 5–8 pounds per square inch, which can be generated by lavaging wounds using a 35 mL syringe and 18 gauge needle or catheter. Commercially available wound lavage units or a sink sprayer (tap water) may also be used. Warmed fluids should be considered to limit hypothermia, particularly in smaller patients, more extensive wounds, or wounds on the trunk.

Bandaging

Infected wounds are best managed as open wounds until healthy, at which time closure or reconstruction may be considered. When wounds communicate with a body cavity, the cavity should be evaluated, lavaged with warm, sterile isotonic solution, and drainage established through the use of a thoracostomy tube or closed-suction abdominal drain. A basic bandage includes the following components.

- *Contact layer*: directly interacts with the wound surface. A number of wound dressings are available and have been extensively reviewed elsewhere. This layer should ideally provide a protected, moist wound environment without macerating the tissue surrounding the wound. Some contact layers have antimicrobial properties or can be used with topical ointments that may provide a useful complement to systemic antibiotic therapy.
- *Secondary layer*: provides protection of wound and absorption of wound drainage.
- *Protective layer*: protects the bandage from dislodgment and environmental contamination.

Bandages should be changed as needed. During the first 1–2 days of wound evaluation (when further sharp debridement may be needed) or with more traditional dressings such as wet-to-dry, the bandage should be changed every 12–24 hours. Bandages should be changed when wound fluid reaches the protective layer of the bandage (also referred to as strikethrough). Some contact dressings such as alginates are intended to be left in place for 3–5 days.

Negative pressure wound therapy (NPWT) has been recently described as an alternative to conventional wound management. A number of NPWT devices are on the market, with increasing expansion into the veterinary field. NPWT can facilitate the development of a healthy granulation tissue bed following initial wound debridement without the need for frequent dressing changes.

Wound Closure

Wound closure is often possible in small animals due to the elasticity and quantity of truncal skin and availability of versatile axial pattern and other skin flaps. Wound closure or reconstruction of an infected wound should not be attempted until the wound is free of debris and necrotic tissue, a healthy wound bed is established, appropriate antimicrobial therapy has been started, the periwound tissues are healthy (not erythematous, macerated, or edematous), and the patient in good health. Many wounds, particularly those on extremities, are difficult to reconstruct or close and may be managed until contraction and epithelialization complete the healing process (second intention healing). Wounds in the perineal region are often best left to heal by second intention because of the difficulty of maintaining bandages in the area. In these cases, owners can be instructed to lavage the wound once or twice daily with tap water with a conventional shower head and apply an antimicrobial cream such as silver sulfadiazine to the area. An e-collar is provided to prevent self-trauma.

Prognosis

The prognosis for wound infections is variable depending on the source, location, and extent of infection (local vs systemic, deep vs superficial). Wound infections are often not amenable to a "quick fix." Owners should be counseled that management of an infected surgical or traumatic wound will likely require serial anesthesia and surgery to debride and potentially to later close the wound. Owners will need to accept that plans to reconstruct or close the wound may be delayed based on the appearance of the wound, and that multiple bandage changes or home wound management may be necessary. In some cases, the consequences of wound infection can negate the benefit associated with a surgery, such as for a total joint replacement. Fortunately, most appropriately managed wound infections can be satisfactorily managed, with patients returning to excellent health and quality of life.

Public Health Implications

Surgical wound infections with antibiotic-resistant bacteria are of significant human and animal health concern.

Bite Wounds

Etiology/Pathophysiology

Although dog and cat bite wounds are managed similarly to other infected or traumatic wounds (see earlier), the frequency and potential severity of bite wounds seen in small animal practice merit particular discussion.

Dogs can bite with significant force, and the orientation of their teeth results in puncture wounds from the canine and crushing or lacerating wounds from the incisor and molar/premolar teeth. Dogs also pull and shake victims following bites, resulting in avulsion of cutaneous vasculature and subcutaneous tissue. Dog bite wounds can be relatively minor lacerations and puncture wounds, or can be associated with extensive, life-threatening injury. Particularly severe are "big dog/little dog" injuries to small dogs or cats in which the victim is lifted and shaken by the aggressor. Although the limbs, head, and neck are common sites, injuries to the thorax and abdomen are relatively common in small-breed dogs. Dog bite wounds can be superficially dramatic, but often the skin wounds are the "tip of the iceberg," with extensive damage and contamination of underlying tissues lying deep to several small puncture wounds.

Due to the presence of contamination and the potential for serious tissue injury, dog bite wounds can lead to the systemic inflammatory response syndrome (SIRS) and septicemia. Without appropriate therapy, patients that survive the initial attack can die of these sequelae. It is important to recognize that a patient that seems relatively stable on initial presentation following a dog attack can rapidly progress to SIRS and septicemia.

Epidemiology

All bite wounds are considered to be contaminated due to the inoculation of the wound with the oral flora of the biter, the skin flora of the victim, and the bacteria or fungi in the environment. The common flora of the canine and feline oral cavity has been reviewed elsewhere, with *Pasteurella multocida* commonly cultured from both species.

Cat bite wounds are more likely to become infected due to the inoculation of oropharyngeal bacteria into deeper tissues. Cat–cat bite wounds are often not diagnosed until an abscess and associated clinical signs develop.

It is important to consider that organisms that cause hematologic disease such as hemotropic mycoplasmas and *Babesia gibsoni* are likely transmitted by bite wounds and follow-up testing may be warranted in some patients.

Signalment

Though any dog or cat can sustain a bite wound, smaller (≤10 kg) male dogs are overrepresented. Studies have identified higher percentages of certain breeds within this number, including Jack Russell terriers, dachshunds, pinschers, Yorkshire terriers, and Maltese dogs.

History and Clinical Signs

Dogs suspected or known to have been in a dog fight, particularly if multiple dogs were involved or if a size disparity was present, should be encouraged to undergo prompt evaluation by a veterinarian.

Diagnosis

The patient should be thoroughly examined, with prompt initial attention paid to cardiovascular and respiratory systems. The clinician should be ready to establish intravenous access and provide respiratory support if necessary through supplemental oxygen, intubation, tracheostomy, or thoracocentesis if indicated. A complete neurologic examination should be performed, particularly if wounds affect the head, neck, back, or extremity. Following initial assessment and stabilization, radiographs of the thorax and abdomen with or without focused assessment with sonography for trauma (FAST) scan for pleural and peritoneal fluid are warranted for wounds over the trunk. However, the absence of apparent free air or other abnormalities on radiographs does not guarantee that damage to the thoracic or abdominal body wall is not present.

Acute bite wounds are not infected, so wound cultures are often not helpful. More chronic wounds should be sampled for aerobic and anaerobic bacterial cultures.

Therapy

Initial stabilization will depend on the condition of the patient and will not be discussed in detail here, but should include the prompt administration of antibiotics. Intravenous administration of a broad-spectrum antibiotic or combination of antibiotics with good activity against skin and oropharygeal flora is warranted. As with infected surgical or traumatic wounds, it is wise to cover the open wound with a clean dressing and to wear gloves during initial assessment to prevent cross-contamination of the wound and hospital environment during assessment and stabilization.

As for infected surgical and traumatic wounds, surgical debridement and the establishment of drainage are important tenets in the successful management of dog bite wounds. The patient is carefully evaluated and the hair liberally clipped in wounded areas. In patients with thick hair coats, it may not be possible to evaluate for smaller puncture wounds without removing hair along the majority of the neck and trunk. The presence of multiple bites is common and, as mentioned earlier, small puncture wounds can be the only external indication of significant damage to deeper tissues.

After stabilization and anesthesia, the skin is prepared as noted in the general section discussing management of infected wounds. After skin preparation and draping, the wounds should be opened and aseptically explored to determine the extent of tissue damage. Simply probing the cutaneous defects is insufficient for bite wounds. Once each wound area is explored, and debris and devitalized tissue removed, the wound is lavaged with isotonic fluid such as normal saline or LRS. Once opened, wounds can be left open and bandaged or, if minimally extensive, closed with appropriate placement of a drain. The reader is referred to surgical texts for a more detailed description of drain placement.

If there is any doubt about the state of the wound, if the wound is already infected, or if it is particularly severe, the author's preference is to leave wounds open and bandage them for several days. Delayed primary closure or tertiary closure may be pursued when the patient is stable, the wound bed is healthy, and the clinician is sure that no further tissue necrosis will occur.

Prognosis

As for infected traumatic and surgical wounds, the prognosis associated with bite wounds varies with the severity and location of the wound and the general health status of the patient.

Public Health Implications

In a dog or cat that has been or may have been bitten by a wild animal, potential rabies exposure protocols consistent with state regulations should be followed. All draining wounds in cats in particular should be handled with appropriate precautions due to the potential for sporotrichosis and other zoonotic diseases such as tularemia.

Further Reading

Cheadle WG. Risk factors for surgical site infection. *Surg Infect* 2006; **7**(Suppl 1): S7–11.

Fry DE. The continued challenge of *Staphylococcus aureus* in the surgical patient. *Am Surg* 2013; **79**(1): 1–10.

Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol* 1992; **13**: 606–8.

Nelson LL. Surgical site infections in small animal surgery. *Vet Clin North Am Small Anim Pract* 2011; **41**(5): 1041–56.

Shamir MH, Leisner S, Klement E, *et al*. Dog bite wounds in dogs and cats: a retrospective study of 196 cases. *J Vet Med A* 2002; **49**(2): 107–12.

Tobias KM, Johnston SA, eds. *Veterinary Surgery: Small Animal*. St Louis, MO: Saunders, 2012.