
Abstract:

Animal bites are a frequent reason for visits to the emergency department. Bite injuries are particularly important in pediatrics as more than half of victims are children. Although most bite wounds heal uneventfully, infectious complications are common. Emergency physicians should be familiar with the approach to the assessment and management of bite wounds and the treatment of infections that may occur. This article will review the epidemiology, management, and prevention of animal bite infections, including those from humans, dogs, cats, and other vertebrates.

Keywords:

bite injury; animal bites; human bites; children; rabies; tetanus prophylaxis

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Bite Wound Infections

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A 5 year-old boy presents with complaints of a swollen, red and painful right hand 1 day after being bit on the hand by his neighbor's Chihuahua. The parents report that the initial bite didn't seem that bad. It was a small bite from a tiny dog. They washed it with soap and water, applied an antibiotic ointment and a Band-Aid. They were shocked to see that it had become so nasty looking after only one day. On exam, the boy's right hand was very tender and markedly swollen. The palmar aspect was erythematous with purulent drainage easily expressed from a small open wound.

Hand surgery was consulted and the child was taken to the operating room for debridement. Gram stain of the wound revealed gram-negative coccobacillus, gram-positive cocci and gram-positive rods. Cultures were positive for *Pasteurella multocida*, *Streptococcus mitis*, and *Corynebacterium canis*. The child's infection gradually improved after several days of IV ampicillin-sulbactam and he was discharge home on oral Augmentin.

The boy is now afraid of small dogs, but is making friends with his cousin's chow-mixed breed...

Animal bites are a frequent reason for emergency department visits, accounting for approximately 1% of all encounters.¹ They are particularly important in pediatrics as more than half of victims are children.² Although most bite wounds heal uneventfully, infectious complications are common. Therefore, emergency physicians should be familiar with the approach to the assessment of bite wounds and the management of infections that may result from them. This article will review the epidemiology, management, and prevention of animal bite infections, including humans, dogs, cats, and other vertebrates. Infections associated with insect bites and other nonvertebrates will not be considered.

EPIDEMIOLOGY

Pet ownership in the United States is widespread, with an estimated 36.5% of households owning at least 1 dog and 30.4% owning at least 1 cat. Specialty and exotic pets, including fish, reptiles, ferrets, hamsters and other rodents, birds, and a variety

of other exotic animals are owned by an estimated 10.6% of US households. As opposed to ownership of cats and dogs, which has been very stable at current levels over the past decade, overall ownership of specialty and exotic animals has decreased from levels in 2006 (16.5%).³ Regardless, pet ownership is widespread in the United States, and therefore, the potential for bite injuries is substantial.

Dogs

Recent data on the frequency of dog bite injuries are lacking. However, almost 2 decades ago, it was estimated that approximately 4.5 million of such injuries occurred each year in the United States.⁴ As dog ownership has increased since that time, it is almost certain that the incidence of bites has increased as well. Multiple studies have found that these injuries are more common in children, most frequently involve the extremities, and usually result from the victim's pet.^{5,6} Although rare in comparison with the overall frequency of bites, approximately 20 to 30 fatal dog attacks occur each year.^{4,7} Certain breeds of dogs have been implicated more frequently in dog bites, particularly for severe and fatal attacks. These include pit bulls, German shepherds, and other large breeds.^{6,8} However, denominator data are lacking, making an estimate of the risk by breed impossible to estimate accurately. In addition, the concept of high-risk breeds has not been confirmed in all studies examining the issue.^{9,10} Furthermore, several studies have demonstrated that breed identification is frequently inaccurate, making reported studies of attack rates by breed further suspect.^{11,12}

Regardless, it is clear that large dogs are capable of inflicting very significant injury. Resulting wounds are characterized by laceration, avulsion, and crush injuries. The jaws of large breeds can exert an estimated force of up to 450 lb/in², sufficient to penetrate sheet metal.¹³

Cats

National data for cat bite injuries are lacking. However, it is estimated that they are much less frequent than dog bites, accounting for only 5% to 10% of animal bites in the United States each year. In a study reported from El Paso, Texas, there were 2177 dog bite investigations in a single year compared with 343 cat bites. Cat bites were more likely to be provoked (89.4%) than dog bites (57.5%). Interestingly, in this study, adults and females were more likely to be cat bite victims, whereas children

and males were more likely to be victims of dog bites.¹⁴ As with dog bites, it is difficult to estimate the true prevalence of cat bites as most are minor and go unreported. Despite the usual benign nature of cat bites, the resultant puncture wounds that they often create increase the likelihood of infection compared with canine bites.

Exotic Pets, Wild Animals, and Livestock

Wild and exotic animal bites are much less frequent than dog and cat bites but do account for a substantial number of bite injuries. Data from Indiana indicate that they account for approximately 5% of bites in that state.¹⁵ Squirrels were the most common wild animal identified in that series. Among exotic animals, reptiles are among the most commonly owned. In 2011, there were more than 4 000 000 turtles, snakes, and lizards kept as pets in the United States.³ Likewise, it has been estimated that more than 15 000 monkeys are kept as pets.¹⁶ Data for the frequency of ownership and bite prevalence due to other exotic pets are lacking. Finally, livestock may inflict bite wounds but are not subject to mandatory reporting, and therefore, data in regard to these injuries are largely anecdotal.

Human

Human bites are thought to be the third most common type of mammalian bite.¹⁷ Once again, accurate descriptive statistics are not available. In addition, much of the available data relating to human bites involve adults. Human bites have a long-standing reputation as being particularly severe and prone to infection. This fearsome reputation has been called into question in more recent studies. As with reports of other bite injuries, those involving human bites often have selection bias, with more severe injuries resulting in patients seeking medical attention being studied, whereas more minor injuries in which no physician visit occurred being excluded.¹⁸ More recent studies of human bites, including studies of children, suggest that the overall rate of infection is much lower than previously suggested.^{19,20}

ASSESSMENT AND MANAGEMENT

History

Management of bite wounds begins with a careful history. Emphasis should be on identification of the biting animal as well as the circumstances under which the bite occurred. In particular, an attempt to

ascertain whether the bite was provoked is important, as unprovoked bites may be at greater risk for rabies transmission. In the case of human bites, the possibility of child abuse should also be considered. The presence of underlying immune compromising conditions should be sought. For example, anatomical or functional asplenia and liver disease greatly increase the risk for severe disease due to some organisms.²¹ In addition, the victim's immunization status should be elicited, especially with regard to tetanus immunization.

Physical Examination

The location, type, and depth of wounds should be determined. Adequate wound exploration may necessitate local or regional anesthesia as well as sedation. Range of motion should be established, particularly if the wound involves a joint, and neurovascular function documented. If the wound is not fresh, an assessment for signs of infection should be made, including an examination for the presence of surrounding erythema, wound discharge, lymphangitis, and lymphadenopathy.

Special attention should be given to bites that involve the hand. They are typically classified by mechanism: occlusional, due to bites sufficiently forceful as to break the skin, and closed fist bites, occurring when a clenched fist impacts the teeth of another individual during a fight. The former mechanism is more common in human bites involving children, but the latter is potentially of greater concern. The resulting injury over the dorsum of the fingers may appear trivial but can easily result in penetration into the tendon sheath. The result may be a severe closed space infection.²²

Wound Cleansing and Debridement

Wounds should be thoroughly cleansed. Although the optimal irrigant is not known, a variety of solutions, including normal saline, Lactated Ringers, tap water, and dilute solutions of povidone-iodine, have been recommended. Regardless of the agent chosen, the wound should be thoroughly irrigated under pressure. This may be achieved by using an 18- or 19-gauge needle or catheter attached to a large syringe.²³ As noted above, adequate exploration and cleansing may require administration of anesthetic agents. Any devitalized tissue should be removed, and a careful search for retained foreign material should be undertaken. In the case of closed fist injuries with suspected violation of the tendon sheath or joint space, early consultation with a hand specialist should be sought.

Wound Closure

Minor bite wounds routinely should be left unclosed. This is particularly true in those wounds with an increased risk of infection, including crush injuries, punctures, those involving hands and feet, wounds greater than 12 hours old, those occurring in immunocompromised hosts, and those caused by cats.

The admonition to leave bite wounds open may not be entirely warranted. Studies of closure in cases of mammalian bites have indicated that proper selection and wound preparation may make the risk of primary closure acceptably small to warrant its consideration²⁴⁻²⁶

Wound Cultures

Culture and Gram stain of fresh wounds are not warranted. Although a variety of organisms may be visualized on Gram stain or isolated in culture, the results of these studies have not been found to be predictive of the risk of subsequent infection or the organisms involved in such infections.^{27,28} For wounds with evidence of infection, culture of material obtained by swabbing or aspiration of the wound should be sent for aerobic and anaerobic culture, particularly in the case of exotic animal bites where data regarding the most common organisms are sparse.

Tetanus Prophylaxis

The need for tetanus prophylaxis should be considered in all children with bite injuries. The resulting wounds should be considered contaminated. As such, children who have received less than 3 doses of tetanus toxoid or whose immunization status is not known should receive tetanus immune globulin. Tetanus toxoid should be administered as well. In this situation, for children younger than 7 years, the preferred tetanus toxoid containing vaccine is DTaP. For those 7 years and older with incomplete immunizations, TdaP is the preferred vaccine.

For children with a history of 3 or more tetanus toxoid doses, tetanus immune globulin is not indicated. For those who have received a tetanus toxoid containing vaccine within the prior 5 years, no further tetanus immunization is warranted. For those whose last tetanus vaccine was greater than 5 years previously, a dose of tetanus toxoid should be given. In this circumstance, a combined vaccine containing diphtheria toxoid is preferred. In the case of those aged 10 to 18 years who have not yet received TdaP, this is the preferred formulation.²⁹

Rabies Prophylaxis

The need for rabies prophylaxis should be considered in all cases of mammalian bites. Any bite from a rabid animal involving a break in the skin contaminated with saliva represents the potential for rabies transmission. Decisions regarding immunization should be based on an assessment of the risk factors present in each case.

The risk of rabies varies by animal species and circumstances surrounding the bite. Unprovoked bites may indicate a greater likelihood of rabies in the biting animal. In the United States, raccoons, skunks, foxes, and bats are the animals most likely to be infected. However, a variety of other animals, including coyotes, cattle, dogs, cats, and ferrets, may be infected. Conversely, most rodents (mice, rats, and squirrels) and lagomorphs (rabbits) are unlikely to be infected with rabies, and rabies prophylaxis is rarely indicated when the biting animal falls into one of these groups.³⁰ Exceptions include large rodents such as woodchucks.³¹

Whenever possible, the rabies vaccination of the biting animal should be determined. Fully vaccinated dogs, cats, and ferrets are at low risk for transmission. When rabies vaccination status of these 3 species is not current or the status is unknown, observation for a period of 10 days is indicated. If any behavior suggestive of rabies develops, the animal should be euthanized, and the brain examined for evidence of rabies. For other species when the biting animal is available and is deemed to fall into a high-risk category (see above), the preferred option is immediate euthanasia of the animal and examination for rabies. In circumstances where the biting animal is not available, the decision must be individualized. Generally, any bite due to a wild animal in a high-risk category would indicate rabies vaccination. For other animals, consultation with local public health authorities is helpful in determining the need for rabies prophylaxis.³²

When indicated, rabies vaccine should be given as soon as possible after the bite occurs. Two formulations are currently available in the United States: human diploid cell vaccine and purified chicken embryo cell vaccine.³³ Although a 5-dose regimen was originally recommended, a shortened 4-dose (days 0, 3, 7, and 14) schedule is now standard.³⁰

Antibiotic Prophylaxis

The use of antibiotic prophylaxis for animal bites has been the subject of controversy and conflicting recommendations for many years. Relatively few controlled trials have been conducted. The limited data available have mostly been obtained for dog,

cat, and human bites. In 1980, Callaham²⁸ conducted one of the earliest controlled trials of bite wound prophylaxis. He studied dog bites and concluded that antibiotic prophylaxis was effective in reducing the frequency of wound infections, but only with high-risk injuries. Despite this and other studies, the effectiveness of antibiotic prophylaxis remains controversial. A 1994 meta-analysis of prophylactic antibiotics for dog bite wounds concluded that they were effective in decreasing the risk of infection.³⁴ However, a more recent Cochrane review concluded that efficacy in most dog and cat bites remains unproven and that the data suggesting efficacy for human bites are very limited. There was also limited evidence for efficacy in the case of bites involving the hand.³⁵

Given the paucity of evidence supporting or refuting antibiotic prophylaxis, a reasonable approach is to reserve antibiotics for the highest risk wounds, especially those involving extensive crush injuries and those in which adequate irrigation is difficult (eg, puncture wounds). If a decision is made to use antibiotic prophylaxis, a reasonable choice is amoxicillin/clavulanate. Although no controlled trials establishing its superiority for this indication are available, its spectrum of activity, including streptococci, anaerobes, *Pasteurella* species, and *Eikenella corrodens*, makes it a logical choice.

Regardless of whether antibiotic prophylaxis is prescribed, discharge instructions should include a description of signs and symptoms of infection with instructions to seek follow-up immediately should they develop. For all but the most trivial injuries, consideration should be given for a wound check 48 hours after the event.

TREATMENT OF ESTABLISHED INFECTION

Microbiology

The microbiology of bite wounds is complex. Studies of bites from a variety of different species indicate that clinically infected bite wounds often yield mixed flora. The most common infecting organisms are normal oral flora for the biting animal; skin flora of the bite victim; or, to a lesser extent, organisms that arise from the environment. Although there is considerable overlap in the range of organisms causing bite wound infections regardless of biting species, there are some differences in frequency as well.

Dogs

In a multicenter study of infected dog wounds, the most frequent organisms isolated were members of

the normal canine oral flora.³⁶ The most frequently isolated aerobes included *Pasteurella* spp (most commonly *Pasteurella canis*), streptococci, *Neisseria* spp, and *Corynebacterium* spp. Among anaerobes, *Fusobacterium*, *Porphyromonas*, *Prevotella*, *Propionibacterium*, *Bacteroides*, and *Peptostreptococcus* were the most common isolates. Most wounds yielded multiple organisms, with a median of 5 isolates per wound.³⁶ In addition to these more commonly isolated organisms, dog bites may be associated with infections with less well-known species, such as *Capnocytophaga canimorsus*.^{21,37} Despite the infrequency of infections due to this organism, it remains an important consideration because it may result in severe infection, leading to sepsis and death. Although this is primarily a consideration in patients with immunocompromising conditions such as splenic dysfunction and alcoholism, fatal infection from the organism has been described in otherwise healthy individuals.³⁸

Cats

In the same multicenter study cited above, cat bite infections had a distribution of infecting organisms similar to dog bites. Once again *Pasteurella* spp were the most frequent isolates. However, *Pasteurella multocida* was the most common species isolated in contrast to the *P canis* most commonly found in dog bites.³⁶

Humans

As for infections from other mammalian bites, most human bite wound infections are polymicrobial, including aerobic and anaerobic species.³⁹ Frequently isolated aerobes include a variety of streptococcal and staphylococcal species. In addition, *E corrodens* is a frequent cause of infections after human bites.⁴⁰ In addition, the anaerobes reported in human bite infections are more likely to be β -lactamase producers than those obtained from nonhuman bite infections.⁴¹

Other Animals

The relative frequency of infecting organisms with other types of animal bites is difficult to estimate due to the infrequency of such injuries and the lack of systematically collected data. Nevertheless, a number of case reports and case series have reported a large variety of organisms that cause infections in this setting. For example, tularemia secondary to a squirrel bite has been reported.⁴² Pig bites have been associated with a number of infecting agents, most commonly streptococcal and staphylococcal organisms, but also *Pasteurella* spp.⁴³ Infected nonhuman primate bites have been

associated with a range of organisms similar to that found with human bites, including streptococci, staphylococci, *E corrodens*, and anaerobes.⁴⁴ The oral flora of reptiles, including snakes, lizards, and alligators, includes a variety of gram-negative organisms, including *Aeromonas hydrophila*, and bite infections due to this organism have been reported.^{45,46}

Surgical Management

The surgical approach to infected animal bites is similar to that for any other infected wound. The wound should be debrided and any abscesses drained. The possibility of retained foreign material should be considered, and careful exploration of the wound undertaken if this possibility cannot be ruled out.

In addition, the possibility of injury to underlying structures should be considered. This is especially true for bites involving the hand, where involvement of the flexor tendons, bones, and joint space may occur.⁴⁷ Another high-risk situation involves dog bites to the head, especially when the victim is an infant. Despite apparently innocuous scalp injuries, penetration of the skull may occur, and studies to investigate this possibility should be considered.⁴⁸

Antibiotic Management

Controlled trials of antibiotics in the management of established bite wound infections are lacking. Therefore, selection of antibiotics should be guided by the antibiotic susceptibility patterns of the most likely infecting organism. For more minor infections, amoxicillin/clavulanate orally provides excellent coverage for the organisms most commonly encountered in bite infections due to dogs, cats, and humans and is recommended by both the Red Book Committee of the American Academy of Pediatrics as well as the Infectious Diseases Society of America. For children allergic to β -lactam agents, reasonable alternatives include an extended-spectrum cephalosporin or trimethoprim-sulfamethoxazole plus clindamycin. More serious wound infections necessitating intravenous therapy may be treated with ampicillin-sulbactam.^{49,50} In communities with high rates of methicillin-resistant *Staphylococcus aureus*, the regimen should include an agent active against that organism, especially if Gram stain of material from the wound suggests the possibility of a staphylococcal infection. Depending on local susceptibility patterns, the severity of the infection, and the age of the patient, clindamycin, vancomycin, trimethoprim-sulfamethoxazole, and a tetracycline are reasonable choices.

Prevention

Because the prevalence and potential severity of bite wound infections, effective strategies to prevent animal bites are warranted. Because of the frequency with which bite injuries are encountered in the emergency center, there is an opportunity to provide parental education about risk reduction strategies.⁵¹ Unfortunately, no rigorously proven preventive strategies are available.⁵²

Despite the absence of high-quality evidence regarding bite injury risk reduction strategies, a number of common sense approaches have been suggested. Before acquisition of any pet, careful consideration should be given to the developmental readiness of the child. Certain pets, including ferrets and other wild animals, are not appropriate for young children.

As dogs inflict the great majority of bite wounds, children should be instructed in appropriate behavior when around these animals. They should be taught not to approach strange dogs, not to run past dogs, avoid direct eye contact, not approach a feeding dog, and never to intervene with dogs involved in a fight.⁵³ Young children, especially those in the preschool years, should never be left alone with a dog. Finally, female and neutered male dogs are preferred as pets for households with children as they pose a decreased risk of bite injury.⁵⁴

SUMMARY

Animal bites are a frequent cause of visits to the emergency center. The risk of infection varies by biting animal and nature of the injury. Risk may be reduced by proper wound management and perhaps by antibiotic prophylaxis in selected cases. Treatment of established infection is similar to the management of other wound infections, with antibiotic selection being based on the most likely infecting organisms. Although of unproven benefit, education may be helpful in reducing the risk of bite injuries and, thus, bite infections. ☒

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