ANIMAL BITES

Epidemiology

Reliable statistics on animal bites are hard to come by, as many bites are not reported. The Centers for Disease Control and Prevention (CDC) in the United States currently estimates that 4.5 million dog bites occur per year, affecting nearly 1.5% of the population, but only 20% (885,000) of victims seek medical attention. Emergency department (ED) visits for dog bites decreased 14% between 2001 and 2008, but hospital admissions for dog bite-related injuries increased 86% from 1993 to 2008, with 9% of patients requiring some type of surgical repair.

The majority of fatalities occur in children younger than 10 years, with children younger than 4 years at greatest risk of death; those older than 50 years also have a higher fatality rate. The breeds most frequently responsible for fatalities include pit bull (59%), Rottweiler (14%), American Bulldog and Siberian Husky (5% each), and German Shepherd Dog (3%), followed by 14 other breeds with one or two fatalities each year. The majority of fatalities involved an unrestrained dog on the owner’s property (59%).

The incidence of bites from species other than dogs is harder to ascertain. Some government reports combine statistics on mammalian bites with those on bites from reptiles and insects or marine envenomations. Geographic differences in incidence add to the challenge. The cat bite generally appears as the second most common animal bite injury in the United States, accounting for 5 to 15% of domestic animal bites. Most cat bites occur in or near the home, and the perpetrators are pets rather than strays (more than 80%). Whereas victims of dog bite injuries are more often male, females are twice as likely as males to be victims of cat bites, with a peak age incidence in the third decade.

Rodent bites are probably the third most common animal bite, representing up to 7% of the total in the United States. Bites from other species combined (monkeys, ferrets, raccoons, foxes, livestock, bats, minks, and other wild animals) total less than 2% of all bites.

Epidemiology changes with locale. In India, for example, dog bites (92%) are followed by monkey bites (3.2%), cat bites (1.8%), and fox bites (0.4%) in terms of frequency.

PRINCIPLES OF DISEASE

Bites can cause damage to skin, muscle, blood vessels, nerves, tendons and tendon sheaths, joints and joint spaces, and bony structures. Some bites involve major trauma and fatalities. The head and neck are areas of particular vulnerability in children younger than 4 years. Less serious, but far more frequently, bite injuries involve contusions, abrasions, lacerations, avulsions, or puncture wounds. Secondary considerations in all of these animal bite wounds involve contamination with oral flora from the biting animal and local infection. The potential for tetanus or rabies exposure must also be considered. Tetanus is discussed in Chapter 59, and rabies is covered in Chapter 131.

Dog Bites

Dog bite force can exceed 310 pounds, although most bites use much less force. Total bite force generated increases as the size of the animal skull increases. Dog bites may cause relatively superficial tearing, or crush injuries that damage skin, subcutaneous tissues, and occasionally muscle and far less commonly tendons, bones, or joints. The wounds may be contusions or ecchymoses without a break in the skin but more commonly are abrasions, lacerations, avulsions, or large gaping crush wounds. A study of more than 2000 dog bites found that most injuries were superficial and most of the patients were treated with simple medication, dressing, or suturing.

Face, scalp, and neck wounds occur most commonly in young children. In children up to 2 years old, there are case reports of dog bites that have perforated the skull, resulting in open depressed fractures, brain laceration, intracranial abscess, and meningitis. The trauma associated with dog bite injuries has led to residual post-traumatic stress disorder (PTSD) in children. In victims older than 15 years, more than 80% of dog bite injuries are on the extremities, with the lower extremities more frequently involved. In adults, dog bites rarely result in fracture, vascular injury, or tendon and nerve damage, but there have been cases of tendon lacerations and purulent tenosynovitis. Bites from police dogs have a much higher risk of causing damage to deeper structures, in particular vascular injury; tendon and nerve injury, as well as fracture and infection, are all more common in bites from police dogs than from civilian dogs.

The incidence of infection from dog bites has historically been quoted as 5 to 15%, similar to the overall infection rate of 7% in nonbite lacerations. More recent work suggests a nonbite laceration infection rate of 3 to 4%, and a recent controlled study of dog bite lacerations showed a baseline infection rate of 2% in the control arm. The type of wound appears to influence infection rates, with avulsions at 3%, lacerations at 6%, and puncture wounds the highest at 7%. In one study of infected bite wounds, 60% were punctures, 10% lacerations, and 30% a combination of the two. Location on the body also affects risk; dog bites on the
hand have a higher rate of infection, and bites of the face have a lower risk than bites elsewhere.23,26

Bacteriology

More than 100 different organisms have been isolated from infected dog bites. Most infected wounds are polymicrobial, with an average of five isolates per wound, including both aerobic and anaerobic species.16,27 No single organism was responsible for more than 30% of infections.28,29 *Staphylococcus aureus*, alpha-hemolytic and beta-hemolytic streptococci, *Klebsiella*, *Bacillus subtilis*, *Pseudomonas*, Enterobacteriaceae, and *Capnocytophaga canimorsus* are among the frequently isolated aerobic organisms.7,30 Anaerobic organisms isolated from infections include *Bacteroides*, *Fusobacterium*, *Peptostreptococcus*, *Porphyromonas*, and *Prevotella* species.16 Although much attention has been focused on *Pasteurella multocida*, its role in causing infections in dog bites may be overestimated.29,31 *P. multocida* is found in the oral flora of 77% of cats but only 13% of dogs.32 *Pasteurella* species are isolated in 25 to 50% of infected dog bite wounds, although one study of infected dog bites found no *Pasteurella*.27,33 The *Pasteurella* species that have been isolated from dogs, such as *Pasteurella stornatis*, *Pasteurella canis*, and *Pasteurella dagnatis*, are less virulent varieties.27,32 When *P. multocida* is isolated from infected dog bites, it is frequently found in mixed culture with other organisms; with infected cat bites, however, *P. multocida* is often the sole pathogen.27

*Capnocytophaga canimorsus*

*C. canimorsus* is a fastidious gram-negative rod that can cause overwhelming sepsis. It is part of the normal oral flora of both dogs and cats. More than 100 cases have been documented since the organism’s discovery in 1976.34,35 About 90% of cases are attributed to contact with a dog, primarily bites or scratches, but for approximately one quarter of infections, only dog contact (without a bite) is documented. A few infections have resulted from contact with cats. About 10% of cases appear unrelated to animal exposure. The disease tends to strike patients with alcoholic liver disease, functional or surgical asplenia, or lung disease or those taking corticosteroids. However, in 40% of victims, no underlying illness is identified.34,36

The illness usually begins within 3 days of exposure (range 1-10 days). Early manifestations include fever, chills, myalgias, and vomiting.27 The clinical picture on presentation is often that of sepsis, with hypotension, renal insufficiency, and disseminated intravascular coagulation (DIC). Purpura, particularly on the face, and petechiae are frequent findings and may progress to symmetrical peripheral gangrene.38 Cutaneous gangrene at the site of the bite strongly suggests *C. canimorsus*.39 Waterhouse-Friderichsen syndrome (adrenal hemorrhage) may occur, as well as metastatic infection, with endocarditis, meningitis, or peritonitis. The mortality rate is 30%, with 70% of deaths occurring in immunocompromised patients.37,39

*C. canimorsus* grows slowly and requires special media and growth conditions. In cases of sepsis without an obvious source when contact with a dog or cat has occurred, *C. canimorsus* should be considered, and the laboratory should be notified to prevent cultures from being misidentified or discarded prematurely.27 Although cultures may take up to 14 days, the organism can sometimes be identified in the patient’s blood smear at the time of presentation, or in blood culture media before macroscopic growth.39,40 Polymerase chain reaction (PCR) has recently proven valuable in *C. canimorsus* identification.41,42

Cat Bites

Cat bite injuries contrast sharply with dog bites in their propensity for infection and injury to deeper structures. The typical cat bite is a puncture wound, but abrasions, lacerations, and avulsions may also occur. Cats have long, slender, pointed teeth that can penetrate tendons, joints, and bone, inoculating bacteria deep into these tissues. The majority of these bites involve the hand and upper extremity.23,43 The puncture wound itself often can be difficult to explore, irrigate, or débride. Cat bites are also more likely than dog bites to become infected.23,43 The incidence of infection in untreated cat bites is reported to be as high as 67%, although this probably represents an overestimate as many patients seek treatment only after infection has developed.26,44 One prospective ED study of patients with cat bites found an infection rate of 16%, and most infections were present when the patient first sought care.9 In addition to generally recognized patient risk factors for infection, predictive factors for cat bite infection also include wound type, depth of penetration, and delay in seeking care.

Bacteriology

A bacteriologic analysis of infected cat bites found a median of five bacterial isolates per culture (range, 1-16), with mixed aerobic and anaerobic bacteria in 63%. Aerobic isolates alone grew in 32% of infected cat bites, and there were no infections caused solely by anaerobes. The most common pathogens were *P. multocida* and *Pasteurella septica*, found in 75%, but streptococci, staphylococci, *Moraxella*, and *Bacteroides* were also isolated among the aerobic pathogens. Anaerobes included *Bacteroides*, *Fusobacteria*, *Porphyromonas*, and *Prevotella*. Only 4% of the cat bite isolates included *S. aureus*, and no *Streptococcus pyogenes* isolates were detected, suggesting the wounds were more heavily contaminated with oral flora of the biting animal rather than the skin flora of the victim.27

*Pasteurella multocida*

An important factor contributing to the risk of infection after cat bites is the presence of *P. multocida*, a highly virulent, facultatively anaerobic, gram-negative rod found in the oral cavity or nasopharynx of 70 to 90% of healthy cats.32 Wound infections and abscesses caused by *P. multocida* have occurred after cat scratches as well as cat bites and less often after dog bites or open wounds that have been licked by dogs.23 *P. multocida* infections have also been reported after the bite of an opossum, rat, lion, rabbit, pig, wolf, monkey, and cougar.45-47
P. multocida wound infections often have an earlier onset than typical skin organisms, causing a rapidly progressive cellulitis apparent within 6 hours and easily identifiable within 24 hours. Presenting features include erythema, warmth, swelling, and tenderness, and often purulent drainage, lymphangitis, and adenopathy. In addition to cellulitis, P. multocida can cause abscess, tenosynovitis, joint infections, and osteomyelitis at the site and may seed articular joints and prosthetic valves, causing septic arthritis, endocarditis, and osteomyelitis at distant sites. Meningitis and pericarditis caused by P. multocida after a bite have also been reported.

In vitro, P. multocida is sensitive to penicillin, ampicillin, tetracycline, fluoroquinolones, amoxicillin-clavulanate, second- and third-generation cephalosporins, and trimethoprim-sulfamethoxazole (TMP-SMX). For prophylaxis, Pasteurella species are considered susceptible to all of the agents previously listed, plus doxycycline, clarithromycin, and azithromycin. The organism is resistant to vancomycin, clindamycin, and oral first-generation cephalosporins and shows borderline susceptibility to aminoglycosides. Semisynthetic penicillins, such as dicloxacillin, have only minimal activity against P. multocida in vitro, and erythromycin is also a relatively poor choice.

Other Mammals

Primates

In the United States, monkey bites appear most commonly in university centers in laboratory workers who have sustained work-related injuries. Primate bites are said to have a high wound infection rate. The infecting organisms have not been well described, with the exceptions of one wound infection caused by Eikenella corrodens and a case of osteomyelitis caused by P. multocida.

The major concern with monkey bites is B virus exposure. Only one of the 35 herpesviruses identified in nonhuman primates, cercopithecine herpesvirus 1, or B virus, causes disease in humans. Other terms for this virus include herpesvirus simiae, herpesvirus B, and monkey B virus. The virus has serologic cross-reactivity with herpes simplex virus (HSV) type 1 and type 2, which cause herpetic lesions in humans. Monkeys of the genus Macaca (macaques) can carry B virus throughout their lives, and B virus disease in monkeys resembles that of human herpes viruses. Asymptomatic infected monkeys harbor the virus in their conjunctiva, buccal mucosa, and genital areas, and may shed virus but are more likely to do so when ill, under stress, immunocompromised, or breeding.

More than 40 cases of B virus infection in humans have been reported, all in laboratory workers bitten or scratched by monkeys or sustaining local injury from animal cages. Many exposures were considered trivial at the time of injury. B virus can enter the victim host cells within 5 minutes, making immediate wound care at the scene (soap and water scrub) the most important step in prevention of transmission. The incubation period may range from 2 days to 5 weeks, but most human cases manifest within 5 to 21 days, with initial symptoms of paresthesias at the site of the bite, soon followed by a vesicular rash and, if untreated, by encephalitis and coma. The case fatality rate is approximately 70%. Treatment with intravenous acyclovir is most successful if begun when local vesicles first appear, but even after central nervous system symptoms develop, aggressive treatment may allow survival.

Rodents

Rodent bites cause small puncture wounds with a low risk of local wound infection. These bites are frequently seen in laboratory workers, in children in lower socioeconomic areas who are bitten while sleeping, and occasionally in pet owners. A number of diseases may be transmitted by rodent bites or scratches, including rat-bite fever, leptospirosis, tularemia, spirocheliosis, murine typhus, and plague, although nonbite contacts are the more common routes of transmission of systemic disease to humans. Rat-bite fever, caused by Streptobacillus moniliformis or Spirillum minus, is rare. It usually manifests 1 to 3 days after the bite with abrupt onset of fever, chills, myalgias, and headache, followed by a rash. Abscesses form in many tissues, including brain, myocardium, and soft tissues. Involvement of joints occurs in 50% of patients, resulting in an asymmetrical migrating polyarthritis. Penicillin is the antibiotic of choice, and the organisms also have sensitivity to erythromycin, cephalosporins, tetracycline, carbapenems, aztreonam, clindamycin, and vancomycin. There is intermediate sensitivity to aminoglycosides, fluoroquinolones, and chloramphenicol, with resistance to TMP-SMX, polymyxin B, and nalidixic acid. Routine prophylaxis is unnecessary, as there is a low rate of wound infection.

Ferrets

The European ferret (Mustela putorius furo) is the third most popular pet in the United States, with an estimated 5 to 7 million pet ferrets in 4 to 5 million households. The ferret is descended from the polecat, a member of the weasel, mink, and wolverine family. Hunters previously bred ferrets to hunt rats and rabbits. They are extremely ferocious and tenacious with their prey. Although domesticated for more than 2000 years, the ferret appears to retain its instinctive propensity for attacking sucking animals and an attraction to the neck of its victim. Ferrets are known to attack infants and young children suddenly and without provocation, even in the presence of an adult. They usually attack the face and neck and often have to be pried off the victim. Extensive cosmetic repair after such attacks has been required.

Domestic Herbivores

The bites of horses may result in severe soft tissue contusions and abrasions, often involve the limbs, and may lead to soft tissue infections with Staphylococcus, Pasteurella, Yersinia, Actinobacillus, Burkholderia, and Rhodococcus species. Some 1800 patients per year visit EDs with horse bite injuries, and on rare occasions, these bites result in systemic infection. Streptococcus equi subsp. zooepidemicus is one of the group C streptococcal species that are common pathogens and is associated with the equine respiratory infection known as strangles but may also be carried by healthy animals. It has been reported to cause meningitis in humans.

Cattle do not have upper incisors, so they virtually never bite. Pig bites, on the other hand, are often deep and may appear deceptively small on the surface. They require careful exploration and débridement. Pathogens include Pasteurella aerogenes, P. multocida, Escherichia coli, Bacteroides, Proteus, and alphapand beta-hemolytic streptococci. Despite antibiotics and appropriate wound care, pig bites have a high risk of infection. Most domestic herbivores carry P. multocida. Bacterial isolates from these animals are often resistant to common antibiotics, which has been attributed to the practice of adding antibiotics to their feed.

Camels are well known for biting their handlers, reportedly in sudden vengeance for offenses committed previously. Unlike most other herbivores, the camel has canine teeth and can cause deep wounds, fractures, and amputations, most involving the handler’s upper limbs. These wounds are reported to have a very high rate of infection.
Wild Animals

Human encounters with large wild animals, such as wolves, coyotes, large cats, elephants, or bears, may result in massive trauma and death, from some combination of biting, goring, or trampling. Attacks by such animals may cause blunt or penetrating trauma, with major arterial blood loss, airway damage, intracranial penetration, broken ribs and vertebrae, pneumothoraces, and intrapitoneal bleeding.71,88 Hyenas are known for their tremendously strong jaws and for their attacks on humans in Africa. Hyenas target the nape of the neck; their teeth may enter or decapitate a human. Bites of bears usually result in multiple punctures, with crushing and tearing of soft tissues, and underlying fractures of facial bones and those of the upper extremity. Big cats tend to attack the nape of the neck; their teeth may enter the pharynx, esophagus, and intervertebral space. A common killing mechanism is to shake the victim by the neck.68 The organisms involved in wild animal bites include staphylococci, streptococci, and anaerobes, similar to bites from domestic animals.16

Infection Risk Factors

As with nonbite lacerations, the location, type of wound, time to treatment and patient factors contribute to the risk of wound infection.68,70 Dog bites in patients who delay care by as little as 6 hours have an increased risk of becoming infected.43,70 Certain patient comorbidities increase bite wound infection risk. Asplenia, cirrhosis, lung disease, and steroid use all increase the risk of Capnocytophaga infections. The risk of Pasteurella infections is increased in patients with alcoholism, rheumatoid arthritis, or diabetes mellitus, those taking steroids, and those who have residual lymphedema after radiotherapy70 (Table 61-1).

Table 61-1 Risk Factors for Bite Wound Infection

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>HIGH RISK</th>
<th>LOW RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>Cat</td>
<td>Dog (excluding hand)</td>
</tr>
<tr>
<td></td>
<td>Human</td>
<td>Rodent</td>
</tr>
<tr>
<td></td>
<td>Primate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pig, camel</td>
<td></td>
</tr>
<tr>
<td>Location of wound</td>
<td>Hand</td>
<td>Face</td>
</tr>
<tr>
<td></td>
<td>Over joint or superficial</td>
<td>Scalp</td>
</tr>
<tr>
<td></td>
<td>tendon (CFI)</td>
<td>Muscosa</td>
</tr>
<tr>
<td></td>
<td>Through-and-through oral</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Below the knee</td>
<td></td>
</tr>
<tr>
<td>Wound type</td>
<td>Puncture</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>Extensive tissue damage</td>
<td>Superficial</td>
</tr>
<tr>
<td></td>
<td>Contaminated or devitalized tissue</td>
<td>Clean</td>
</tr>
<tr>
<td></td>
<td>Old (delayed presentation) or</td>
<td>Recent</td>
</tr>
<tr>
<td></td>
<td>sutured</td>
<td></td>
</tr>
<tr>
<td>High-risk patients</td>
<td>Immunosuppressed, HIV positive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transplant patient, steroid dependent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diabetes, cancer chemotherapy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prosthetic valve patients</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peripheral vascular disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elderly, alcoholic, cirrhosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Social and compliance problems</td>
<td></td>
</tr>
</tbody>
</table>

CFI, closed-fist injury; HIV, human immunodeficiency virus.

MANAGEMENT

Bite injuries, particularly those from monkeys with potential exposure to herpesvirus simiae (B virus), should be immediately cleansed with soap and water at the scene.16,64 Washing the wound with soap and water, ideally with the use of a fine-pore sponge to minimize additional tissue trauma, also substantially decreases the risk of rabies infection if done within 3 hours.77 Key elements of the history include the circumstances of the bite, type of animal, animal immunization status against rabies, animal behavior, and whether the animal is available for observation. Specifically ask about comorbidities with risk of poor wound healing (e.g., diabetes, peripheral vascular disease); use of immunosuppressive medications or steroids; history of splenectomy; chronic alcoholism, particularly with malnutrition; and parenteral recreational drug use. Assess the tetanus status, medication allergies, and primary care provider availability.72 Potential language, cultural, or economic barriers to compliance are additional considerations.14 Active bleeding is controlled with direct pressure. If necessary, a temporary 3-0 nylon suture on a large needle may be used. Intractable bleeding on an extremity may be controlled with a proximal blood pressure cuff inflated above the systolic pressure for up to 20 minutes.

The general principles of wound management apply to these patients (see Chapter 59). Radiographs are usually not necessary but may be considered when there is the possibility of bony injury or foreign body. Infants and children up to 2 years old who sustain substantial bite wounds to the scalp may require computed tomography (CT) imaging.88 In most situations, exploration with local anesthesia or procedural sedation will be critical. The importance of adequate visualization of the depths of the wound cannot be overstated, as this may be the sole opportunity to detect a foreign body or a deep structure injury that could otherwise be missed and manifest later with increased morbidity. In the absence of deep structure injury, wound irrigation followed by conservative débridement is recommended. There is no evidence that extension of the wound to promote irrigation diminishes the chance of infection.

Much controversy and few data surround the question of suturing animal bites. Sound practice dictates that when a wound is at high risk for infection, it should not be sutured unless there is evidence of its safety or other compelling reasons. One study of 145 sutured bite wounds (dog, cat, and human) found a rate of infection of approximately 6%. The use of antibiotics was not standardized.73 This infection rate may be acceptable in lacerations for which cosmesis is a primary concern. To date, only dog bites have had controlled studies to address the issue of primary closure.43 The infection rate in 169 wounds was the same for sutured bites as for those left to heal by secondary intention (7.7%). Dog bites on the hand had a higher infection rate (12%), but there was no significant difference between sutured and unsutured wounds. Other studies have demonstrated an equivalent infection rate for sutured dog bites and unsutured wounds.29,74 On the face, sutured dog bite wounds have a very low infection rate, even when punctures are sutured and no prophylactic antibiotics used.75

The following guidelines are suggested, even though data are limited (Table 61-2). Bite wounds of the face and scalp from any species that are less than 6 hours old may be irrigated and sutured. It is probably safe to suture most other uncomplicated dog bites. Lower extremity and hand wounds are at higher risk for infection and should rarely be sutured. Cat bites and primate bites should not be sutured in locations other than the face and scalp. Puncture wounds, contaminated wounds, wounds more than 12 hours old, or wounds infected at presentation should not be sutured. Patients at risk for infection or poor wound healing are best treated conservatively without suturing. See Chapter 59 for a discussion of...
wound healing with delayed primary closure. No current evidence shows that topical adhesive closure as opposed to sutures changes the rate of infection.

**Prophylactic Antibiotics**

A Cochrane review including eight randomized controlled trials concluded that prophylactic antibiotics did not reduce the overall rate of infection after bites by cats or dogs. The type of wound (laceration or puncture) did not have any relationship to the effectiveness of the prophylactic antibiotic. There was evidence from one trial that the use of antibiotic prophylaxis after bites of the hand was associated with a statistically significant reduction in the rate of infection, but the authors also concluded that additional confirmatory research was required.

**Dog Bites**

In general, prophylactic antibiotics are not indicated for routine dog bite wounds, except those of the hand. The most recent randomized controlled trial to address this showed a control infection rate of 4.3% (2 of 46 patients, confidence interval [CI] 0–7%) with a prophylactic antibiotic infection rate of zero (0 of 48 patients). The difference was not statistically significant. A reasonable approach, therefore, would be to give prophylactic antibiotics to high-risk patients and to those with dog bite wounds of the hand or other high risk wounds (see Table 61-1).

Data to support one prophylactic regimen over another do not exist, either in terms of antibiotic choice or in terms of duration. A variety of antibiotics have been used for prophylaxis in studies, including penicillin, dicloxacillin, co-trimoxazole, cephalaxin, Ceflor, Kefzol, and erythromycin. A recent review recommended amoxicillin-clavulanate or a combination of penicillin plus cephalaxin, and moxifloxacin or combination therapy with ciprofloxacin and clindamycin for penicillin-allergic patients, although many of these regimens have not been tested in randomized studies and, given the bacteriology, it is not clear that an antibiotic covering *Pasteurella* species is essential in prophylaxis. The most recently studied approach has been the use of amoxicillin-clavulanate (Augmentin) for 3 days (Table 61-3).

Coverage for *P. multocida* is recommended in established wound infections; amoxicillin-clavulanate and the second- and third-generation cephalosporins are all excellent first-line agents. Alternative regimens and those for penicillin-allergic patients can be used. The dosage and duration of treatment are individualized to the patient, the site of the infection, and the clinical severity of the presentation. Most patients do not require hospital admission. The incidence of methicillin-resistant *Staphylococcus aureus* (MRSA) in dog bite wound infections has not been studied, and coverage for MRSA in prophylaxis or infections is currently not recommended. Oral colonization of the animal mouth by MRSA is unlikely, and therefore MRSA coverage would not be expected to add anything unless the patient had risk factors for MRSA (e.g., previous MRSA infections, or close contact with a known MRSA reservoir).

**Capsyctophaga canimorsus**

There are no studies on the prevention of *C. canimorsus* infection, but it is probably prudent to give prophylactic antibiotics to immunocompromised patients (including diabetics) after a dog or cat bite. In vitro, *C. canimorsus* is susceptible to penicillin G, ampicillin, carbenicillin, cephalexin, cefotaxime, clindamycin,
erythromycin, tetracycline, fluoroquinolones, vancomycin, and chloramphenicol, although one clinical case of resistance to penicillin, erythromycin, and clindamycin has occurred. C. canimorsus displays variable susceptibility to TMP-SMX and appears to be resistant to all aminoglycosides. For prophylaxis, amoxicillin-clavulanate or penicillin is recommended. For treatment of established infections, use of a parenteral second- or third-generation cephalosporin, amoxicillin-sulbactam, or clindamycin plus a fluoroquinolone (in adults) is acceptable. C. canimorsus continues to appear in sepsis of obscure cause, and a history of exposure to dog bites should be actively pursued in these situations.78,79

Cat Bites

There is only one published randomized controlled study of prophylactic antibiotics in cat bites; though small, it demonstrated reduced infection.44 A Cochrane review concluded there was no evidence that antibiotic prophylaxis was effective for cat bites, although the authors also concluded that animal bites on the hands (where most cat bites occur) benefit from prophylaxis.76 We therefore recommend prophylaxis including coverage for P. multocida as well as S. aureus and Streptococcus species. MRSA coverage is not indicated because it is not an oral pathogen for the cat. Pasteurella is usually sensitive to penicillin, although some β-lactamase–producing strains have been recovered. Pasteurella is also usually sensitive to ticarcillin, amoxicillin-clavulanate, tetracyclines, second- and third-generation cephalosporins, fluoroquinolones, and TMP-SMX. P. multocida may be resistant to semisynthetic penicillins (dicloxacillin, methicillin) as well as erythromycin, clindamycin, first-generation cephalosporins, and aminoglycosides.51

For prophylaxis, amoxicillin-clavulanate or a second-generation cephalosporin such as cefuroxime is recommended. For penicillin-allergic patients, moxifloxacin or clindamycin plus ciprofloxacin will cover the likely pathogens. Extended-spectrum fluoroquinolones cover P. multocida and have good staphylococcal and streptococcal coverage. Azithromycin may be effective for penicillin-allergic patients but has less activity against anaerobes.44,80,81

For very high-risk bites, such as cat bites on the hand, intravenous antibiotic prophylaxis in the ED should be considered. Although there are no experimental data to support this strategy, intravenous treatment achieves detectable levels in the wound much sooner than the oral or intramuscular route.

Other Animal Bites

Although there are no studies to support the practice, antimicrobial prophylaxis for bites from other mammals is often provided.16 We recommend antibiotic prophylaxis with coverage against Pasteurella for pig bites or camel bites, for high-risk patients, and for bites on the hand. Rodent bites and those from most other species have a lower risk of wound infection, so prophylaxis is not indicated. The anecdotal data available on wild animal bites suggest that the organisms involved are similar to those in domestic animals, including staphylococci, streptococci, and anaerobes.16 There are no studies regarding the use of antibiotic prophylaxis in these injuries.82

Prophylactic Antiviral Agents

Monkey Bites

Immediate management at the scene, including cleaning the wound with soap and water for at least 15 minutes, is paramount. Mechanical cleansing of the area is more important than the type of solution used. Mucosal surfaces should be rinsed with running water for 15 minutes. Immediate irrigation is thought to inactivate and wash out virus that may be present in the wound. In the ED, management includes a determination of the health status of the monkey and the historical details of the exposure; however, most reported human infections with B virus were transmitted by asymptomatic animals. Regardless of prior irrigation, repeat wound cleansing should be performed. Cultures of the bite are generally not recommended before irrigation, and they are often negative afterward.

Although human cases of infection are extremely rare given the thousands of potential exposures each year, the mortality rate for B virus infection in the absence of antiviral therapy is over 70%. Treatment with antiviral medication may decrease the death rate; rapid diagnosis and therapy are essential in controlling central nervous system spread of the virus.34 Prophylaxis with antiviral therapy is individualized based on the risks of the exposure (Box 61-1). The dialogue with the patient regarding antiviral prophylaxis should be documented. If prophylaxis is undertaken, the recommended therapy is valacyclovir (1 g orally [PO] q8h × 14 days) or acyclovir (800 mg PO 5 times daily × 14 days). Prophylaxis can be started up to 5 days after the exposure.53 Patients should be told about the early symptoms of B virus infection and immediately seek care if any develop. Patients should also be advised to avoid exchange of bodily fluids, including saliva, or handling of an open wound or vesicles, as one case of human-to-human transmission has occurred.54

Monkey bites are also considered to be at high risk for bacterial wound infection; prophylactic antibiotics covering S. aureus, anaerobic cocci, and Bacteroides are recommended for full-thickness bites, particularly those on the hand.53 Good choices include amoxicillin-clavulanate or moxifloxacin.

Other Prophylaxis

Rabies and tetanus prophylaxis should be considered for all bite wounds.

DISPOSITION

Patients with any of the following should be considered for hospital admission: delayed presentation (>24 hours), established infection at the time of presentation, deep structure violation, high-risk patient or high-risk wound categories, and social support or compliance issues (Table 61-1). Those with cosmetic issues requiring surgical repair such as large facial wounds also may require admission.

HUMAN BITES

Epidemiology

The majority of human bite wounds (60-75%) involve the hand or upper extremity. Although the overall infection rate for human bite wounds has been estimated at 10%,43,84 human bites of the hand, especially the fight bite or closed-fist injury (CFI), are associated with a higher incidence of infectious complications. Simple human bites elsewhere on the body are probably no more significant than nonbite wounds. The reported rate of infection in human bites of the hand is 25 to 50%,59 but the majority of these infections already exist when the patient first seeks care.83,86 The high infection rate results from a number of factors: the relative lack of vascular supply to structures in the hand, the position of the hand at the time of injury, the mechanism and force of injury, the bacteriology of the human mouth, and a delay in seeking care.


**Box 61-1 Prophylaxis for Monkey B Virus Exposure**

**Prophylaxis Recommended**
Skin exposure (with loss of skin integrity) or mucosal exposure to a high-risk source; macaque that is ill, immunocompromised, known to be shedding virus or has visible lesions compatible with B virus
Inadequately cleaned skin or mucosal exposure
Laceration of head, neck, or torso
Deep puncture wound
Needle-stick associated with tissue or fluid from the nervous system, lesions suspicious for B virus, eyelids, or mucosa
Puncture or laceration after exposure to objects (1) contaminated with fluid from monkey oral or genital lesions or with nervous system tissues or (2) known to contain B virus
Postcleaning culture-positive B virus

**Prophylaxis Considered**
Mucosal splash that has been adequately cleaned
Laceration (with loss of skin integrity) that has been adequately cleaned
Needle-stick involving blood from an ill or immunocompromised macaque
Puncture or laceration occurring after exposure to either objects contaminated with body fluid (other than from a lesion) or potentially infected cell culture

**Prophylaxis Not Recommended**
Skin exposure in which the skin remains intact
Exposure associated with nonmacaque species of nonhuman primates


In a study of 50 patients with infected human bites, 56% of the injuries were CFIs; the rest were “occlusal” injuries, most on the hand.83,87 The infections may progress to purulent tenosynovitis, septic arthritis, and osteomyelitis.

**PRINCIPLES OF DISEASE**

**Fight Bites (Clenched Fist Injury)**

A CFI results when the patient strikes another person in the mouth with a closed fist during an altercation. The patient’s recollection to discuss the event may preclude an accurate history. This historical ambiguity combined with patient compliance issues may make management of these injuries even more challenging.83,84 The CFI manifests as a minor laceration of the dorsum of the hand, most commonly over the middle finger metacarpophalangeal joint (third MCP joint), but other MCP joints are frequently involved.88 The small laceration may involve deep structure injury to the extensor tendon sheath, the tendon itself, bones, or joint spaces. Joint penetration occurs in up to 62% of these wounds, and up to 58% involve injury to bone.89 “Chondral divot fractures” result from a tooth striking the articular surface of the joint and chipping off fragments of articular cartilage. The incidence of these fractures varies from 6 to 30% in retrospective studies, and up to 58% in one prospective study, with an incidence of tendon damage as high as 34%.78 The presence of an extensor tendon laceration is highly predictive of joint penetration, and patients with deep structure involvement have significantly increased morbidity from the CFI. Infection of the joint space (pyogenic arthritis, septic joint) may be aggressive and rapidly destructive to the joint tissues.87 Deep space infection of the hand leading to amputation has also been reported.16 These wounds may contain foreign bodies. Associated bony injuries include the boxer’s fracture (distal ring or small finger metacarpal fractures), and occlusive bite injuries may cause traumatic amputation of the digit.

**Other Human Bites**

Human bites in locations other than the hand treated with proper local wound care have a rate of infection similar to that of ordinary lacerations. Human bites of the face have about a 2.5% infection rate. In children, approximately 70% of human bites are abrasions, which generally do not become infected. The reported infection rate of human bites in children is 9% to 12%, similar to the 10% infection rate of all human bite wounds quoted earlier, although the data in children come from older studies. Most of these infections are noted at the time of the initial visit, usually in patients who have delayed care for more than 12 to 18 hours.90,91 Lacerations from the victim’s own teeth, usually a result from a fall or a seizure, are considered bites. Wounds that involve only the mucosa or tongue have a low infection rate, from 0 to 12%, but mucocutaneous (through-and-through) lacerations have an infection rate as high as 30% in the absence of prophylactic antibiotics, so the latter warrant prophylaxis. Organisms cultured from these infected wounds include Streptococcus, Staphylococcus epidermidis, Bacteroides, Corynebacterium, Neisseria, and Haemophilus haemolyticus.92

**Human Bite Bacteriology**

The oral flora of the human mouth includes a high concentration of pathogenic organisms. Human saliva contains up to 50 different species of bacteria.85 Not surprisingly, bite wounds have numerous bacteria of multiple species, and the bacterial count increases dramatically several hours after the injury.96 Cultures of uninfected bite wounds, however, do not predict which patients will become infected, or which pathogen will be responsible.89 Information on the bacteriology of infected human bites comes almost exclusively from hand bites, with the majority of these being CFIs. Infected wounds are polymicrobial. Streptococcus anginosus is the most common pathogen, found in 52% of infections, followed by S. aureus and E. corrodens, each in 30%.96 Earlier studies found a predomination of Staphylococcus and Streptococcus species, followed by Corynebacterium species and Eikenella.33,88 Oral anaerobes are also often present in these wounds16 and account for more than half of the isolates.83 Anaerobes and gram-negative rods are more frequently isolated from infected human bites on the hand than other types of hand infections, including those from animal bites, and the presence of anaerobes in a mixed infection may be associated with a worse outcome. The gram-negative organisms isolated include E. corrodens, diphtheroids (Corynebacterium species), Haemophilus, and coliforms.98

E. corrodens is a facultatively anaerobic gram-negative rod harbored in human dental plaque and found in 6 to 30% of CFI infections.16,88,93 It acts synergistically with aerobic organisms, most frequently streptococci, and was historically thought to account for greater morbidity in these wounds.94 More recent information confirms this synergistic activity but indicates that infections involving E. corrodens are no more serious than other infections.98 E. corrodens is usually susceptible in vitro to penicillin, ampicillin, second- and third-generation cephalosporins, carbenicillin, tetracycline, and fluoroquinolones.80,81 Resistance to penicillin has been reported.95 E. corrodens is resistant to methicillin, aminoglycosides, clindamycin, vancomycin, and metronidazole.52 Susceptibility to first-generation cephalosporins and erythromycin is limited.81,95

**Transmission of Disease**

Human bites have resulted in transmission of hepatitis B, hepatitis C, tetanus, syphilis, tuberculosis, and herpes.95,96,97 Herpetic
whitlow, infection of the distal phalanx from HSV, is an occupational hazard of nurses, physicians, dentists, and oral hygienists. Although human immunodeficiency virus (HIV) is secreted at some time in the saliva of up to 44% of infected patients, the CDC does not consider human bites to carry a risk of transmission unless there is exposure to blood.91,92 HIV is not often present in patient’s saliva, and when it is, the titer of virus is very low.93 Cases in which HIV has convincingly been transmitted through a bite involved significant amounts of blood mixed with the saliva.94,95 Nevertheless, when a significant bite has occurred, and particularly if the biter is known to be HIV positive, it is reasonable to consult with infection control experts locally or at the CDC.

**MANAGEMENT**

**History**

As with animal bites, information regarding immunosuppression and significant comorbidity with risk for poor wound healing should be elicited. Infections are more common in the very young and the elderly.94 The practitioner should consider tetanus status, medication allergies, social situation, availability of follow-up, and patient reliability. Likewise, the issues of language, cultural, social, or economic barriers to appropriate management and compliance may also play a part in management decisions.

**Wound Evaluation and Management**

The approach to the human bite depends on the location and the mechanism of injury. Any laceration in the vicinity of the MCP joint is considered a CFI. Full-thickness bites on the hand are considered high risk. Radiographs looking for tooth fragments or other foreign bodies, air in the joint space, or bony injuries are appropriate.83,86 A “skyline” view may be required to demonstrate vertical articular fractures of the metacarpals.101

Assess the wound for infection and neurovascular status with particular attention to extensor tendon function in CFI injuries. Examinations that demonstrate injuries to the deeper structures generally prompt consultation with a hand surgeon. Although there are no controlled studies on suturing human bites, the infection rate and complications of human bites on the hand suggest that they should not be sutured; instead, the wound is covered with a dry sterile dressing and the hand is splinted. Human bite injuries elsewhere on the body can be treated as typical lacerations, with irrigation, aggressive débridement, and consideration of suturing if anatomy permits and cosmetic considerations are important.102 Tetanus can be transmitted by human bites.72,103

**Prophylactic Antibiotics**

Antibiotic prophylaxis is recommended for full-thickness human bites of the hand (see Tables 61-2 and 61-3). The only randomized, placebo-controlled study of patients hospitalized with uninfected human bites on the hand found no infections in patients who received antibiotics, whereas those who received placebo had a 47% infection rate.83 Although good results have been achieved historically in selected situations without prophylactic antibiotics when patients were treated early and received appropriate wound cleansing, this is probably not optimum wound management today.83,86 A Cochrane review concluded prophylactic antibiotics were associated with a statistically significant reduction in the rate of infection after bites by humans, although this was based on the single study mentioned earlier.26,83

Irrigation of mucosal or tongue lacerations may be difficult. Suturing is advisable only for deeper and larger wounds. Through-and-through lacerations, from a tooth puncture of the skin of the lower lip, may require a layered closure. Although the one randomized study on prophylactic antibiotics in these lacerations did not find the infection rate to be lowered significantly, a trend toward reduction in infection in the treated group was seen; therefore prophylactic antibiotics may be considered for through-and-through lacerations.82

Prophylactic antibiotics are recommended for high-risk human bite wounds elsewhere on the body, including contaminated wounds, deep punctures, wounds with late presentation, and wounds in patients with underlying comorbidity. Antibiotic prophylaxis should cover gram-positive organisms and *E. corrodens* (see Table 61-3). Prophylaxis for MRSA is not currently recommended, as colonization of the human mouth with MRSA is unlikely.10 When prophylaxis is undertaken, particularly in high-risk situations, we recommend giving the first dose parenterally in the ED.

**Prophylactic Antiviral Agents**

Victims of bites from persons potentially infected with HIV or hepatitis are managed with exceptionally rapid, vigorous, and thorough wound cleansing with soap and water, to remove saliva, followed by irrigation with virucidal agents such as 1% povidone-iodine. A baseline HIV blood test and hepatitis antibody testing should be performed at the time of injury and prophylaxis considered for hepatitis B or HIV if the victim was bitten by someone with these viruses.10 An excellent resource to help sort out the specifics of a given situation 24 hours a day is the CDC’s postexposure prophylaxis hotline (1-888-448-4911) or the website of the University of California San Francisco/San Francisco General Hospital–based National HIV/AIDS Clinicians’ Consultation Center (www.nccc.ucsf.edu).

**Infection**

Infected human bites of the hand require aerobic and anaerobic cultures. The patient should be treated with intravenous antibiotics covering gram-positive organisms, *E. corrodens*, and anaerobes. Anaerobes isolated from human bite wounds produce β-lactamase and are often resistant to penicillin.

**DISPOSITION**

**Patients with Infection**

Delay in presentation and the presence of infection on initial evaluation are both strongly correlated with subsequent morbidity.83,86 All patients with infected human bites of the hand should be hospitalized for parenteral antibiotics (Box 61-2). Localized infections of human bites elsewhere on the body in immunocompetent patients without significant comorbidity can usually be treated without hospitalization if appropriate follow-up can be arranged.

**Box 61-2 Indications for Hospital Admission for Human Bites of the Hand**

- Established infection at the time of presentation
- Deep structure violation (tendon or sheath, joint, bone)
- High-risk wound (foreign body, contaminated, devitalized tissue)
- High-risk patient (see Table 61-1)
- Wound more than 24 hours old (delayed presentation)
- Likely social support or compliance issues
Patients without Infection

Reliable, otherwise healthy patients who are seen within 24 hours of the injury and who have no injury to the deeper structures may be treated on an outpatient basis with close follow-up, preferably within 2 days.83,86 Prophylactic antibiotics as discussed earlier are recommended for human bites of the hand and those at high risk elsewhere on the body (contaminated wounds, later presentation). Suggested regimens include amoxicillin-clavulanate (Augmentin, 500 mg PO q12h) or a second- or third-generation cephalosporin such as cefuroxime (Ceftin, 500 mg PO bid × 5 days). Discharge instructions include immobilization, elevation, and frequent dressing changes initially, along with wound care instructions regarding symptoms that should precipitate an early return for reevaluation.

Patients at higher risk, such as those with deep structure involvement or delayed presentation, require prophylactic parenteral antibiotics in the ED and close evaluation. Consultation with a hand surgeon is usually wise, and hospitalization is generally prudent. In one series, 63% of patients with fight bites either left against medical advice or failed to follow up, and it is reasonable to admit patients who might predictably fall into this category even without associated injuries.88 Although many human bites are a consequence of mutual aggression, the patient may be a victim or perpetrator in child, spousal, or elder abuse.104 All states require reporting of suspected child abuse; laws vary for spousal or elder abuse. In all cases, details of the incident should be documented and the wound(s) described in the record. Counseling or referral should be offered when appropriate.