Human and Animal Bite Infections

Itzhak Brook, MD, MSc
Bethesda, Maryland

Although often innocuous initially, human and animal bites can cause serious local and systemic infections as well as other complications. Bites to a site where joints or bones are close to the skin are especially prone to severe complications. Bites to the hand, therefore, require meticulous radiographic and surgical evaluation if a puncture or a severe laceration has occurred. Since the normal human oral flora harbors more pathogens than that of animals, human bites have a higher incidence of serious infections and complications. The oral flora of both humans and animals is anaerobic-aerobic, and initial empiric treatment requires the most broad spectrum antimicrobial therapy available, in addition to scrupulous wound management and, when required, immunization against rabies and tetanus.

The infection potential of animal and human bite wounds is great, especially when the victim is brought to medical attention more than 24 hours after the event. The infection rate from bites is high because most of the pathogens introduced into the wound originate from the normal aerobic-anaerobic flora found in the oral cavity of the biting human or animal.[1–6] The normal human oral flora, however, is more pathogenic than the animal flora, as is evident from the larger number of organisms recovered in human bite wounds.[2]

Bite wounds may consist of punctures, lacerations, avulsions, and scratches. Even though the teeth of a dog, for example, are not very sharp, they can still exert a pressure of 200 to 450 psi—a pressure high enough to perforate light sheet metal.[7] The result is a crush injury with much devitalized tissue, which encourages infection. Puncture wounds are more likely to become infected than any other type of bite injury.

Osteomyelitis, tenosynovitis, and septic arthritis are common complications of bite wounds where the skin lies close to bone (eg, joints or skull); lymphangitis, meningitis, brain abscess, and sepsis with disseminated intravascular coagulation may also occur.[8–11]

Submitted, revised, November 18, 1988.

From the Departments of Pediatrics and Surgery, Uniformed Services University of the Health Sciences, Bethesda, Maryland. The opinions and assertions contained herein are the private ones of the writer, and are not to be construed as official or reflecting the views of the Department of Defense, the Navy Department, or the Naval Service at large. Requests for reprints should be addressed to Dr. Itzhak Brook, Armed Forces Radiobiology Research Institute, Bethesda, MD 20814-5145.

COMMON SITES AND INCIDENCE

Human Bites

Human bites occur most frequently on the hand and upper extremities (60% to 75% of cases), especially the fingers.[1,12] Human bites might also involve the head or neck (15% to 20%), trunk (10% to 20%), and lower extremities (5%), as well as other sites (5% to 10%).[1,12]

The proximity of many of these wounds to bone, combined with exposure to the potentially virulent aerobic-anaerobic polymicrobial oral flora, explains why human bites are generally more serious than animal bites, with more wounds tending to become infected or to develop the complications described. Human bites to the hands and skull tend to have the most severe sequelae.

Animal Bites

According to the Public Health Service, more than 1 million animal bites requiring medical attention occur in the United States each year.[13] Most of these wounds are caused by dogs, which account for 80% to 90% of all animal bites requiring medical care and for almost 1% of emergency hospital visits.[14] While 50% of all bites are trivial in nature, at least 10% of victims require suturing and follow-up office visits, and 1% to 2% require hospitalization.[15]

Children are especially prone to animal bites on their fingers. In a sample of 1,869 dog bites reported to the New York City Health Department, the majority occurred in patients younger than 20 years of age.[16] In all individuals,

TABLE 1. PREVALENCE OF BACTERIA ISOLATED FROM HUMAN BITE WOUNDS*

Aerobic and Facultative	Percent	Anaerobic	Percent
Staphlococcus aureus	30–45	*Peptostreptococcus* sp	30–75
Staphlococcus epidermidis	10–50	*Propionibacterium acnes*	3
Streptococci		*Eubacterium* sp	3–10
α - hemolytic	25–30	*Veillonella* sp	15–20
β - hemolytic	15–35	*Clostridium* sp	3
γ - hemolytic	3–30	*Fusobacterium* sp	12–40
Neisseria sp	10–15	*Bacteroides* sp	12–30
Corynebacterium sp	25–40	*B melaninogenicus* group	30–50
Eikenella corrodens	10–20	*B oris-buccae*	15
Hemophilus influenzae	5	*B oralis*	6–15
Hemophilus parainfluenzae	10–15	*B disiens*	3
		B corrodens	3

*From Goldstein et al[1] and Brook[2,3]

the extremities—mainly the right hand or arm—are the most common sites for animal bites.

BACTERIAL PATHOGENS

Bacteria associated with infection at the site of a bite wound originate from the normal oral flora of the biting human or animal, where anaerobes outnumber aerobic bacteria in a ratio of 10:1. Occasionally, pathogens may also originate from the environment or from the victim's own skin.

Pathogens Associated with Human Bites

Earlier studies of human bites noted α-hemolytic streptococci and *Staphylococcus aureus* to be the most common organisms isolated from infected bite wounds,[17,18] with the latter most often being correlated with severity of and complications from human bite infections.[19,20] Likewise, the presence of anaerobic spirochetes and fusiform bacilli was noted to correlate with a less favorable prognosis.[17,18] Penicillin-resistant gram-negative rods, alone or in mixed culture, were reported in about one third of bite wound cultures.[20–22] Most of these earlier studies, however, did not employ methods suitable for recovery of anaerobic bacteria.

Recent studies that did use culture methods for anaerobic bacteria indicate that anaerobes are far more prevalent in human bite infections than previously recognized.[1–3] *S aureus* has been recovered in only 25% of patients, whereas organisms originating in the oral flora were recovered in most of them. For example, anaerobes have been isolated in 53% of clenched fist injuries in adults,[1] in 85% of human bites in children,[2] and in 73% of children with paronychia.[3] In the majority of these studies, the anaerobes were mixed with aerobes, and the total number of isolates per infected wound ranged from one to five.

The predominant organisms isolated from human bites are listed in Table 1.[1–3] *Eikenella corrodens* was isolated in 10% to 20% of wounds, α-hemolytic streptococci in 25% to 30%, and anaerobic bacteria in more than 50%. β-Lactamase-producing bacteria were identified in 41%[2] of these wounds, including *S aureus* and *Bacteriodes* sp. These findings confirm that the normal oral flora, rather than the skin flora, is the source of most bacteria isolated from human bite wounds.

Pathogens Associated with Animal Bites

Most studies of animal bite wounds have focused on the isolation of *Pasteurella multocida*,[23,24] disregarding the role of anaerobes. Recent studies of the gingival canine flora[4,5] and of dog bite wounds,[6] however, point toward an oral flora of multiple organisms, most of which are potential pathogens.

Goldstein et al[6] isolated *P multocida* from only 26% of dog bite wounds in adults. The most common aerobic isolates were α-hemolytic streptococci (46% of patients) and *S aureus* (13%). Anaerobic pathogens were present in 41% of wounds, including *Bacteroides* sp (mostly *B melaninogenicus*) and *Fusobacterium* sp (19% of patients each).

Brook evaluated the microbial flora of 17 dog and four cat bite wounds in children, and isolated 37 aerobes and 22 anaerobes[2]; the anaerobes were recovered from 76% of these wounds. The predominant isolates were *S aureus* (33% of wounds), anaerobic cocci (45%) and *Bacteroides* sp (20%) (Table 2).

Human vs Animal Bites

The most striking difference in the microbial flora of human and animal bite wounds is the higher number of mean isolates per wound in human bites—5.4 vs 2.8 isolates per specimen, respectively. This difference is due mainly to the higher isolation rate of anaerobic bacteria (mostly *Bacteroides* sp) in human wounds compared with animal bite wounds—3.0 vs 1.0 isolated per specimen, respectively.

TABLE 2. PREVALENCE OF BACTERIA ISOLATED FROM ANIMAL BITE WOUNDS

Aerobic and Facultative	Percent	Anaerobic	Percent
Staphlococcus aureus	18–33	*Peptostreptococcus* sp	8–45
Staphlococcus epidermidis	10–40	*Veillonella parvula*	4–15
Streptococci		*Propionibacterium* sp	6
α - hemolytic	10–35	*Actinomyces* sp	3
β - hemolytic	6	*Leptotrichia buccalis*	2
γ - hemolytic	6–10	*Fusobacterium* sp	14–20
		Bacteroides sp	4–6
Neisseria sp	6–8	*B melaninogenicus* group	10–15
Corynebacterium sp	10–30		
Eikenella corrodens	5		
Capnocythophaga sp	5		
Bacillus sp	5		
DF-2 organism	2		
EF-4 organism	5–15		
M-5 organism	4		
Hemophilus aphrophilus	2–10		
Hemophilus parainfluenzae	1–2		
Pasteurella sp	6		
Pasteurella multocida	16–18		
Proteus mirabilis	3		
Pseudomonas aeruginosa	2		
Pseudomonas fluorescens	6–15		

From Goldstein et al[1] and Brook[2,3]

P multocida, *P fluorescens*, and *Bacillus* EF-4—known pathogens that are part of the oral flora of the dog—have been recovered only from animal bite wounds.

DIAGNOSIS

The clinical manifestations of a bite wound depend on its source. While symptoms of bites from venomous reptiles (eg, snake, lizard) or spiders may be severe and appear immediately, the initial manifestations of human or dog bites are generally only mild and not that different from a laceration injury. On the other hand, because of the direct introduction of both oral and skin flora into the wound, when an infection does occur from a human or an animal bite, it will progress quite rapidly, usually becoming apparent within 6 to 24 hours.

The following signs and symptoms of an infected bite wound should be anticipated: redness and swelling, clear or pussy discharge, enlargement of adjacent lymph nodes, and the presence of a reduced range of motion of the affected extremity.

In severe cases a peripheral leukocytosis (15 to 30 $\times$ 10^9/L, 15,000 to 30,000 cells/mm^3) and fever, chills, prostration, and nausea or vomiting indicating septicemia may be present.

Assessing the Patient at Risk for Complications

As the sequelae of human bite wounds are generally more severe than those caused by animals, puncture wounds are more likely to become infected than other types of bite wounds, and teeth may cause a deep laceration, thereby implanting oral and skin microorganisms into joint capsules, dorsal tendons, or the skull, all of the following complications may result: septic arthritis, osteomyelitis, tenosynovitis, lymphangitis, meningitis, brain abscess, or sepsis with disseminated intravascular coagulation.[8–11]

Wounds of the hand are especially susceptible to complications because of the proximity of skin to the hand's numerous joints and bones. Infections of hand bite wounds have been reported in 28% of cases, compared with 4% for facial bites.[25] Clenched fist injuries require a particularly thorough evaluation, preferably by a hand surgeon, to assess the degree of damage to the tendons and their sheaths, to the joints and their capsules, or to the bones. Because of these risks, all hands injured by teeth should undergo radiographic examination.[8] The possibility of wound contamination by a foreign body, such as a broken tooth or soil, or bone fractures in the traumatized site and in other parts of the body, should be considered.

Stains and Cultures

A Gram stain to determine the presence of pathogens in the wound may be used. If a culture is required, both animal and human wound specimens should be cultured for aerobic and anaerobic bacteria.

TREATMENT

The rules governing the management of any laceration also apply to bite wounds: cleanse, irrigate, explore, debride, drain, excise, and possibly suture.

- *Cleanse* and irrigate the wound vigorously with soap or with a quaternary ammonium compound, rinsing with plenty of water.
- *Irrigate* the wound, through a 19-gauge needle, with at least 150 mL of sterile normal saline or lactated Ringer's solution.
- *Explore* for damage to tissue by crushing or tearing and for damaged tendons, joints, bones, or blood vessels (using x-ray films when needed).
- *Debride* devitalized tissue. Secondary debridement, including that of necrotic bone, may be required after a few days.
- *Drain* the wound, if necessary, in the customary fashion or with a gentle suction, using a 19-gauge scalp vein tubing connected to a vacuum blood-collecting tube.[26]
- *Excise* the margins of puncture bite wounds, but leave them open after irrigation. A primary closure is recommended only in uninfected wounds. Some wounds, however, can be closed after careful trimming of wound margins. Generally, *closure* of the wound should be considered only after the infection is eradicated. Close the wound by either delayed primary intent after 3 to 5 days, when contamination is eradicated, or by secondary intent.[26]

Treating Bites to the Hand

Bites to the hand have a high risk for severe infection damage because the biting teeth may penetrate the tendon sheaths or the mid-palmar space. The hand should be examined for integrity of nerve and for tendon function. If there is *any* suspicion of serious injury or infection, the exploration and examination should be done by an experienced hand surgeon, using regional blocks and tourniquet control to establish a bloodless field.[27]

In human bites to the hand, the wound should be opened widely, debrided, and thoroughly irrigated, but primary closure or nerve repair should be delayed until after the infection has subsided.[28]

In dog bites to the hand, the wound is considered clear following irrigation, and primary closure should be promptly carried out.

In severe cases of animal or human bites, hospitalize the patient for several days, immobilizing the hand by splinting or with dressings and elevations.

Treating Bites to the Face

These bites require meticulous management to prevent intercranial complications: (1) careful wound debridement, irrigation, and cleansing, (2) use of loose closure by suture (in severe cases, consult a plastic surgeon at the time of the initial repair, and (3) careful follow-up for at least 5 days.

When Infection Is Already Present

Early, thorough, and aggressive treatment of all human and animal bite wounds, and especially those of the hand and skull, can prevent many infections and other complications. Unfortunately, the patient is often brought to medical attention after infection already has occurred. If the infection is severe—as may be evident from abscess formation, cellulitis around a joint, or infection of an entire hand—or when the patient's compliance or reliability is in doubt, consider hospitalization and intravenous antimicrobial therapy.

Selecting Appropriate Antimicrobial Therapy

Antimicrobial therapy should be administered to all patients with human or animal wounds except those with trivial wounds and patients seen 24 hours or more after injury who have no clinical signs of infection. Antimicrobial treatment of bite wounds is considered to be therapeutic, not prophylactic. The infectious complications of both human and animal bites make an aggressive approach essential, especially for high-risk wounds.

Obviously, no single antibiotic can be expected to be effective against infections caused by all the organisms that may be present in an infected bite wound. The choice of a particular agent for prophylaxis or empiric treatment should therefore be based on the expected anaerobic-aerobic potential.

Penicillin is adequate as initial therapy for animal bites. If *S aureus* is suspected (eg, from a Gram stain), add a penicillinase-resistant penicillin such as dicloxacillin. Penicillinase-resistant penicillins, cephalosporins, and clindamycin, however, are less effective against penicillin-susceptible organisms than penicillin when they are used alone and should not be given as empiric therapy.

Penicillin may not be an adequate choice for human bites because of the high frequency of β-lactamase-producing bacteria in these wounds (41% of patients in one study[2]). Penicillinase-producing organisms may not only resist penicillin therapy themselves, but could also shield other penicillin-susceptible pathogens present in the wound from the activity of this drug.[29] The combination of amoxicillin and the β-lactamase inhibitor clavulanate potassium has been shown to be effective in the treatment of both human and dog bites.[30] The effectiveness of this combination is due to its wide spectrum of activity against most pathogens isolated from human and animal wounds, including the most common β-lactamase-producing strains. This convenient one-drug combination has been shown to be as effective and safe as penicillin-V potassium plus dicloxacillin in the treatment of human bite wound infection.[30]

Erythromycin may be used in penicillin-allergic patients. It may be ineffective against 50% of *P multocida* isolates, however. Furthermore, *S aureus* and anaerobic bacteria may become resistant to this agent.[31] Tetracy-

cline, chloramphenicol, or the one-drug combination sulfamethoxazole-trimethoprim provides variable coverage for bite wounds.[31]

E corrodens, a capnophilic gram-negative rod that is part of the normal oral flora,[17] has been isolated from 25% of human bite wounds.[1] It is susceptible to penicillin, ampicillin, and cefoxitin. It is, however, resistant to oxacillin, methicillin, nafcillin, and clindamycin, and some of its strains are resistant to several cephalosporins. If a cephalosporin is considered but *E corrodens* has been isolated, susceptibility testing is necessary.

Parenteral Antibiotics

Parenteral therapy with penicillin is adequate for animal bite infections. If *S aureus* or anaerobes are present, however, the administration of cefoxitin will provide wider antimicrobial coverage against these organisms. Other drugs that provide adequate wide-spectrum coverage are the combination of ticarcillin and clavulanic acid or imipenem.

For empiric parenteral therapy of human bite infections, the broadest aerobic-anaerobic coverage possible is needed, for example, penicillin-G plus a penicillinase-resistant penicillin or a first-generation cephalosporin. Since up to 50% of *Bacteroides* sp isolated from human bite wounds are resistant to penicillin, cefoxitin may be used as an effective single agent. Both regimens would cover *S aureus*, *E corrodens*, most gram-negative rods, and oral anaerobic bacteria. The third-generation cephalosporins, including cefotetan, generally have an inferior activity against gram-positive aerobic cocci (ie, *S aureus*), and are less active against β-lactamase-producing *Bacteroides* sp.

If improvement does not occur promptly despite appropriate antimicrobial therapy, resistant bacteria, abscess formation, or osteomyelitis should be considered.

Duration of Antimicrobial Therapy

The duration of treatment depends on the severity of the infection. A total of 7 to 10 days of antimicrobial therapy generally is adequate. In cases of severe infection (eg, osteomyelitis, septic arthritis), a total of 4 to 6 weeks of parenteral antibiotic therapy followed by oral administration may be required.

In Table 3 are listed various effective oral and parenteral antimicrobial therapies for human and animal bite wounds. Therapy should be tailored according to culture results of the specific patient. When antimicrobial agents are used in the manner suggested, combined with scrupulous wound management, most bite wounds can be sutured with good results and an acceptable infection rate.

Rabies and Tetanus Prophylaxis

Consider rabies prophylaxis if the victim came into physical contact with the saliva of an animal capable of transmitting rabies or if the biting occurred in a geographical area known or suspected to be associated with rabies.[32] Treatment includes hyperimmune serum and active rabies immunization. The recent development of human diploid cell rabies vaccine has markedly reduced the incidence of reactions previously associated with postexposure prophylaxis with duck embryo vaccine.

If the patient has been immunized for tetanus previously and has not received a booster within the previous 5 years, a tetanus toxoid booster should be given (0.5 mL intramuscularly). If tetanus immunization has not taken place, administer a tetanus immune globin (human) and start a primary course of active immunization.

In summary, the cornerstones of bite wound management are as follows:

1. Scrupulous cleansing and debridement, with surgical care when needed
2. Broad-spectrum aerobic-anaerobic empiric antimicrobial therapy until results of culture are available
3. Immunization for tetanus and rabies, as required
4. Assessment of the patient for risk of complication.

By properly managing these common wounds, complications may be averted and recovery will be facilitated.

TABLE 3. SUGGESTED EMPIRIC ANTIMICROBIAL THERAPY FOR BITE WOUNDS*

Administration	Animal Bites	Human Bites
Oral	Amoxicillin-clavulanate potassium	Amoxicillin-clavulante potassium
	or	or
	Penicillin-V potassium	Amoxicillin plus dicloxacillin
Parenteral	Cefoxitin	Cefoxitin
	or	or
	Penicillin G plus β-lactamase-resistant penicillin	First-generation cephalosporin plus β-lactamase-resistant penicillin
	or	or
	Ticarcillin-clavulanate potassium	Ticarcillin-clavulanate potassium

**Change to specific antimicrobial therapy as soon as culture results are available*

References

1. Goldstein JC, Citron DM, Wield B, et al: Bacteriology of human and animal bite wounds. J Clin Microbiol 1978; 8:667–672
2. Brook I: Microbiology of human and animal bite wounds in children. Pediatr Infect Dis 1987; 6:29–32
3. Brook I: Bacteriologic study of paronychia in children. Am J Surg 1981; 141:703–705
4. Laphir DA, Carter GR: Gingival flora of the dog with special references

to bacteria associated with bites. J Clin Microbiol 1976; 3:344–349
5. Baile WE, Stowe EC, Schmitt AM: Aerobic bacterial flora of oral and nasal fluids of canines with reference to bacteria associated with bites. J Clin Microbiol 1978; 7:223–231
6. Goldstein JC, Citron DM, Finegold SM: Dog bite wounds and infections: Prospective clinical study. Ann Emerg Med 1980; 9:508–512
7. Chambers GH, Payne JF: Treatment of dog bite wounds. Minn Med 1969; 52:427–430
8. Szalay GC, Sommerstein A: Inoculation osteomyelitis secondary to animal bites. Clin Pediatr 1972; 11:687–689
9. Bracis R, Seibers K, Juillien RM: Meningitis caused by IIJ following a dog bite. West J Med 1979; 131:438–440
10. Klein DM, Cohen ME: *Pasturella multocida* brain abscess following perforating cranial dog bite. J Pediatr 1978; 92:588–589
11. Findling JW, Pholmann GP, Rose HD: Fulminant Gram-negative bacillemina (DF-2) following a dog bite in an asplenic woman. Am J Med 1980; 68:154–156
12. Marr JS, Beck AM, Lugo JA: An epidemiologic study of the human bite. Public Health Rep 1979; 94:514–521
13. US Public Health Service: Annual summary. 1976; 25:MMWR 1977; 34
14. Thomson HG, Svitek V: Small animal bites: The role of primary closure. J Trauma 1973; 13:20–23
15. Kizer KW: Epidemiologic and clinical aspects of animal bite injuries. JACEP 1979; 8:134–141
16. Harris D, Imperato PJ, Oken B: Dog Bites: An unrecognized epidemic. Bull NY Acad Med 1974; 50:981–1000
17. Manson ML, Koch SL: Human bite infections of the hand. Surg Obstet Gynecol 1930; 51:591–625
18. Welch CE: Human bite infection of the hand. N Engl J Med 1936; 215:901–908
19. Farmer CB, Mann RJ: Human bite infections of the hand. South Med J 1966; 59:515–518
20. Guba AM, Mulliken JB, Hoopes JE: The selection of antibiotics for human bites of the hand. Plast Reconstr Surg 1975; 56:538–541
21. Mann RJ, Hoffeld TA, Farmer CB: Human bites of hand: Twenty years of experience. J Hand Surg 1977; 2:97–104
22. Shields C, Patzakis MJ, Meyers MH et al: Hand infections secondary to human bites. J Trauma 1975; 15:35–36
23. Francis DP, Holmes MA, Brandon G: *Pasteurella multocida* infections after domestic animal bites and scratches. JAMA 1975; 233:42–45
24. Hawkins LG: Local *Pasteurella multocida* infections. J Bone Joint Surg 1965; 51:363–366
25. Callaham ML: Treatment of common dog bites: Infection risk factors. JACEP 1978; 7:83–87
26. Graham WP III, Calabretta AM, Miller SH: Dog bites. Am Fam Physician 1977; 15:132–137
27. Chrinard RG, D'Ambrosia RD: Human bite infections of the hand. J Bone Joint Surg 1977; 59A:416–418
28. Nardi GI, Zuidema GD (eds): Surgery, A Concise Guide of Clinical Practice. Boston, Little, Brown, 1972
29. Brook I: The role of beta-lactamase-producing bacteria in the persistence of streptococcal infection. Rev Infect Dis 1984; 6:601–607
30. Goldstein EJC, Reinhardt JF, Murray PM, et al: Animal and human bite wounds: a comparative study. Augmentin vs. a penicillin + dicloxacillin. Postgrad Med J 1984; (suppl):105–110
31. Goldstein EJC, Citron DM, Vagvolgyi AE, et al: Susceptibility of bite wound bacteria to seven oral antimicrobial agents including RU-985, a new erythromycin: Consideration in choosing empiric therapy. Antimicrob Agents Chemother 1986; 29:556–559
32. Centers for Disease Control. Rabies prevention. MMWR 1980; 29:265