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Review Article

A Review on the Microbiology of the Animal Bite Wound Infection

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ABSTRACT

Animal bite wound infections represent a complex interplay between diverse microbial pathogens and host defences, necessitating a comprehensive understanding of the microbiological landscape for effective management. This review navigates the intricate terrain of etiological agents, host-pathogen interactions, treatment challenges, and future directions in understanding and addressing these infections. Etiologically, a spectrum of bacterial, viral, and fungal agents, including Pasteurella spp., Capnocyto phagacanimorsus, Streptococcus spp., and Staphylococcus aureus, feature prominently in animal bite-associated infections, each harbouring distinct virulence factors and pathogenic mechanisms. Antibiotic resistance presents a pressing challenge, prompting the exploration of alternative therapies amidst escalating resistance trends. Emerging diagnostic techniques, notably molecular methods, hold promise in precise pathogen identification, enabling targeted interventions. Preventive measures, encompassing responsible pet ownership and education on wound management, play a pivotal role in mitigating infection risks. Future research directions focus on innovative diagnostics, deeper insights into host immune responses, and novel therapeutic modalities, aiming to optimize clinical outcomes.

INTRODUCTION

Animal and human bites and other orally contaminated wounds are common, with more than 1 million animal bites occurring annually in the United States Bite wounds typically contain poly microbial flora that generally reflect the aerobic and anaerobic microbiology of the oral flora of the biter, the skin of the victim, and the environment. Bite wounds include scratches, punctures, lacerations, and evulsions. Often these wounds can appear innocuous initially, but frequently lead to serious infection and complications. This review presents the microbiology and management of animal and human bite infections [1-5]. The sustained and worldwide epidemic of animal bite injuries and infections has been the subject of many scholarly reviews, and there has been a plethora of series and case reports but very few systematic studies. Since human-animal contact is a daily occurrence for

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most people worldwide in various settings, from farms to domestic pets to feral animals, it is not surprising that as a result of this contact, bite injuries are caused by a wide variety of domestic and wild animals. Most of these wounds are minor injuries and go unreported, and patients self-administer first aid and often do not seek or require medical attention. In industrialized countries, most patients with moderate to severe bite injuries will seek some form of medical attention whether in an emergency department or in a physician's office. When these injuries are reported, the authors of the reports generally concentrate on unusual or resistant organisms or unusual complications and their management. These retrospective incidents form the basis for anecdotal medical decision-making that is employed worldwide. Very few studies have been systematic and have attempted to define the presentation, epidemiology, bacteriology, and/or therapy of bite wounds. However, even these systematic studies are generally limited to dog or cat bites and involve relatively small numbers of patients, and one must often extrapolate the best form of antimicrobial therapy to employ. One principle that has emerged and is scientifically established is that the bacteria recovered from bite wounds are reflective of the oral flora of the biting animal. In a minority of cases the pathogenic bacteria come from the victim's own skin, often as secondary invaders, or from the physical environment at the time of injury. Thus, bites by aquatic animals have a bacteriology that is reflective of their water environment. A second established principle is that the oral flora of the biting animal not only contains the usual “normal flora” but also is influenced by the microbiome of their ingested prey and other foods. Some of these isolates may be transient, while others are persistent and remain. Most individual elements of bite wound care come from localized “standards of care” or general applications of wound care principles but have never been further validated.

In their lifetime, about half of all Americans will be bitten by an animal or by a person. Since the majority of bite victims never seek medical attention and many of those who do go unreported to local health departments, it is challenging to determine the actual number of bite victims. [6]

It is not shocking that 4/5 million bites are thought to happen yearly, making up about 2% of all ER visits. It is estimated that the annual medical costs associated with treating dog bite wounds alone exceed $100 million. [7] A considerable level of illness and death, coupled with a growing occurrence, has elevated this issue to a substantial public health matter. Reports indicate a consistent rise in insurance claims, with an estimation from one agency suggesting that national claim compensations may surpass $2 billion each year. [8] However, the potential for infection and disfigurement from bites is great, and directly correlates with lack of proper medical attention and inadequate wound care. Unfortunately, due to selection bias towards patients who are seen that do require medical attention, most published studies are cases in which the wound is more severe, the infection potential high, actual infection is present, or legal ramifications exist. The appropriate management of bite wounds remains ill-defined, with antibiotic prophylaxis and surgical management being at the centre of the controversy. This article reviews the available literature and attempts to provide insight into the effective management of these injuries.Animal bite wounds represent a unique intersection of host, environment, and microbial factors, often precipitating a cascade of events that pose considerable challenges in clinical management. The diverse microbial milieu associated with these wounds, influenced by the type of animal, anatomical site, and pre-existing conditions,

underscores the multifaceted nature of infection stemming from these encounters. Bite wounds from both humans and animals, as well as other oral contaminations, are rather common. Over 1 million animal bites that need medical attention happen in the US each year, and these bites make up about 1% of ER visits, according to the US Public Health Service. Bite wounds from both humans and animals, as well as other oral contaminations, are rather common. Over 1 million animal bites that need medical attention happen in the US each year, and these bites make up about 1% of ER visits, according to the US Public Health Service. [9] Bite wound microbiology is typically polymicrobial, reflecting both the environment and the aerobic and anaerobic microbiology of the biter's oral flora and the victim's skin. However, these organisms are frequently missed by clinical microbiology labs. Scratches, punctures, lacerations, and evulsions are examples of bite wounds. Despite the fact that these wounds may initially appear benign, they frequently result in serious infections that could have dire consequences. [10-11] Dog bites are an extremely common problem in the United States. Dog bites account for 80% to 90% of all animal bites requiring medical care [12] and almost 1% of emergency department visits. Although half of all bites are trivial, at least 10% require suturing and follow-up visits, and 1% to 2% of all bite wounds require hospitalization [13]. Most dog bites are in the predominant extremity. Children are especially prone to animal bites, especially of the face. Of 12,777 mammalian bites reported from 1990 through 1992 [14], 25% occurred in children less than 6 years of age, and 34% were in children 6 to 17 years old. Women are more often bitten by cats, and young men are commonly bitten by dogs. Incidents of monkey and simian bites are on the rise, particularly among men, and frequently target the upper extremities, with a notable focus on the hands. These bites typically represent the most severe category of animal bite injuries. Over 130 reported cases highlight complications such as cellulitis, osteomyelitis, tenosynovitis, and flexion contractures. Additional varieties of animal bites encompass those from horses, pigs, and aquatic animals. [15]

Microbiology

Typically, the microorganisms retrieved from bite injuries usually come from the oral cavity of the biting creature and the victim's skin flora. Infections are commonly polymicrobial and exhibit synergistic interactions. In research employing effective techniques for the retrieval of both aerobic and anaerobic bacteria, anaerobes were identified in over two-thirds of infections resulting from human and animal bites, particularly those linked to the formation of abscesses. [16–19]. Streptococcus pyogenes is generally found in human bites, Pasteurellamultocida in animal bites [20], Eikenellacorrodens in both animal and human bites (mostly with the latter), Capnocytophagacanimorsus (formerly Centres for Disease Control and Prevention [CDC] group DF-2) [21], Capnocytophagacynodegmi, Neisseria weaver (formerly CDC group M-5) [22], Weeks ellazoohelcum(formerly II-J) [23], Neisseria Canis [24], Staphylococcus intermedius [25], nonoxidizer-1 [26], and eugenic oxidizer-2 [27] in dog bites, a Flavobacterium group IIb-like organism in an infected pig bite [28], and Actinobacillusspp in horse and sheep bites [29]. Vibrio spp, Plesiomonasshigelloides, Aeromonashydrophila, and Pseudomonas spp have caused infections in bites occurring in marine settings [30]. Serious systemic infections can be transmitted through bites: tularaemia from cats [31], herpes B virus from monkeys, rat-bite fever and sodoku from rats, hepatitis B virus from

humans, leptospirosis from dogs and rodents, and rabies from dogs and other mammals.

Epidemiology

I. Dogs bites

Dogs are the most common animal to bite people, accounting for 80–90% of bite incidents. An estimated 2% of the population is bitten by dogs every year, which means that 914 people in the United States visit emergency rooms every day. According to reports, 50–60% of dog bites occur from German shepherds; however, this breed comes in third for dog bite deaths, behind Rottweilers and Pit bulls. Most dog bites are minor injuries, but 5% to 7% need hospitalization. [32-33]. Typically, individuals affected are young males, usually under 20 years old, with the highest occurrence observed between 5 and 9 years of age. These incidents frequently occur during direct interactions with dogs or while being present on the property of the dog owner. Reports indicate that the dog was provoked by the victim in 30–90% of cases. Bites predominantly happen on the victim's extremities, though the location of the wound varies based on the victim's age. Bites on the face, head, and neck are more prevalent in younger age groups, likely due to the height of the victim. [34]. The risk of being bitten appears to be greatest in the warmer months, particularly during the late afternoon and early evening [35]. Dogs possess large, somewhat blunt teeth and robust jaws, capable of causing substantial damage through crush injuries. Larger dogs can exert a bite force exceeding 450 pounds per square inch, even puncturing light sheet metal. Such crush injuries are frequent and can lead to tearing and devitalization of tissues, increasing the risk of infection. Lacerations, and less frequently, puncture wounds and avulsions, may also be evident. The overall infection rate associated with dog bites is notably lower compared to both cat and human bites, with reported rates as low as 4%. [36-38].

II. Cats Bites

Cats account for approximately 400 000 bites per year, making up 5–15% of all reported animal bites. Cat bites occur most often in women and in a slightly older population than is typically seen in dog bites, with just under half of all victims being over 20 years of age. The highest proportion of bites seem to occur in the spring and summer mornings. Most often, injuries are minor, so victims tend to not seek medical attention. Biting cats are typically stray females, and in a similar fashion to dogs, are provoked in more than one-half of all injuries. Cats may also bite or scratch if their aggression is territorial or predatory in nature, when being petted or playing, or as a defence mechanism if perceiving a potentially harmful situation.

Approximately two-thirds of cat bite injuries target the upper extremities, primarily manifesting as 'scratches' on the hand or fingers. Infection rates have been documented to range between 30% and 50%, surpassing the rate observed in dog bites by more than double. This heightened risk is likely attributed to the fine, sharp teeth of cats. Despite their weaker biting forces, these teeth can penetrate bones and joint capsules, potentially leading to conditions such as osteomyelitis and septic arthritis. [39-41].

III. Human bites

Human bites constitute the third most common mammalian bites, accounting for 2–3% of all reported cases. A study conducted in New York City in 1979 revealed an incidence of 11.8 human bites per 100,000 persons annually. Approximately 75% of human bite wounds stem from overtly aggressive actions, predominantly affecting the dominant hand of males (80–100%) during their teenage and young adult years. Incidents are more frequent on weekends, peaking

in the spring and early summer. Accidental bites also occur, often linked to sports- and school-related activities, with most being superficial and involving the face. It is not uncommon for victims of human bites to delay seeking medical attention, elevating the risk of complications. The overall infection rate resulting from human bites ranges from 15% to 50%. Human bites can be best separated into occlusional and clenched-fist injuries. Occlusional wounds result from teeth sinking into the skin. A review of 67 cases by Vale and Noguchi illustrated an anatomic distribution of occlusional bite marks, relating most often to sexual crimes and child abuse. Almost half the victims suffered multiple wounds during the episode. About 15–20% of occlusional bites are described as 'love nips', associated with sexual activity. Clenched-fist injuries or 'fight bites' have proven to be the most prevalent and severe of human bites. They typically present as small wounds over the metacarpophalangeal joint of the dominant hand, and are caused by striking another person's teeth with a clenched fist. The clenched position allows the teeth easy access into the joint space, with the resulting inoculation sealed into the space when the fingers are re-extended. This type of injury may also result in fractured bones or lacerated tendons. An X-ray is needed to rule-out osteomyelitis, fracture or a retained tooth. Unfortunately, these wounds are not usually attended to until swelling or a purulent drainage appears. Delayed medical intervention may ultimately require hospitalization, intravenous antibiotics and surgery[42-45].

BITE COMPLICATIONS

Various complications can arise from bite injuries, with infection being the most prevalent. Human bite wounds tend to result in more severe sequelae compared to those caused by animals, particularly with puncture wounds being the most susceptible to infection. Mammalian teeth can cause deep lacerations, creating a pathway for the transmission of oral, skin, and environmental microorganisms. Tooth penetration into bones or joints may lead to osteomyelitis, septic arthritis, tendinitis, or tenosynovitis, with rare cases requiring amputation. Bites to the cranium, involving underlying skull fracture, dural laceration, and potential parenchymal injury, can result in central nervous system infections and brain abscesses. Additionally, complications such as endocarditis, lymphangitis, meningitis, and sepsis with disseminated intravascular coagulation have been reported. [46-47]

Diagnosis

The symptoms that emerge following a bite depend on the type of animal inflicting the insult. The immediate local or systemic symptoms can be severe following a bite from a venomous animal (eg, snake, lizard, spider). Human or dog bites generally do not cause immediate symptoms in addition to the laceration injury. However, because of the direct inoculation of oral and skin flora into the wound, an infection can develop rapidly, with signs and symptoms appearing in 24 to 72 hours. The signs of infection include redness, swelling, and clear or purulent discharge. The adjacent lymph nodes may be enlarged, and range of motion of an extremity can be reduced. Leukocytosis may occur, with 15,000 to 30,000 cells/mm3. The observation of an eschariform lesion in a sick-appearing individual may suggest the presence of C. canimorsus infection [48]. Human bites are typically more serious than animal bites, particularly in clenched-fist injuries where the skin over the knuckles is penetrated upon striking another person's teeth. This can result in a deep laceration, introducing oral and skin organisms into joint capsules or dorsal tendons, potentially leading to septic arthritis or osteomyelitis. It is advisable to obtain radiographs of hands injured by teeth for proper evaluation.

[49]. It is very important to determine the medical status of the source of the human bite (eg, infections with a hepatitis virus, HIV status, and other transmittable diseases). About 2% to 5% of all typical dog bite wounds seen in emergency departments become infected . However, the rabies status of the dog should be ascertained in each instance. Wounds that completely penetrate the skin have an infection rate of 6% to 13%, depending on location. In comparison, the infection rate of clean lacerations repaired in the emergency department is about 5% [50]. It is crucial to perform Gram staining and culture for both aerobic and anaerobic bacteria from human and animal bite wounds. Employing culture and microbiological techniques capable of effectively recovering anaerobic bacteria is essential. In instances where wounds are contaminated by soil or vegetative debris, it is advisable to conduct cultures for mycobacteria and fungi as well. Additionally, determining the sedimentation rate or C-reactive protein can assist in cases of osteomyelitis and septic arthritis, aiding in determining the appropriate duration of antimicrobial therapy.

Wound Management

Management of wounds includes proper local care, and use of antimicrobial agent(s) when needed. The steps involved in evaluation and wound care for bites include recording the medical history (animal involved, provoked or unprovoked attack, current medications, splenectomy, mastectomy, allergies, chronic disease, and immunosuppression), examination of the wound and related structures (Odor of exudates, depth, type, location, range of motion, joint involvement, enema or crush injury, nerve and tendon damage, presence of infection), obtaining wound cultures, irrigating the wound with saline, débridement, obtaining radiographs (when bone penetration is suspected), wound approximation, administering antimicrobials, tetanus and rabies immunization when indicated, herpes B virus evaluation (in monkey bites), and re-examination at 24 and 48 hours. The incident should be reported to the local health authorities when indicated. Bites should be managed as any laceration: cleanse, explore, irrigate, debride, drain, and possibly suture. The wounds should be washed vigorously with soap or a quaternary ammonium compound and water. This is of primary importance in reducing the high inoculum of the oral flora of the biting human or animal. The physician should explore for tissue damage caused by crushing or tearing and should search for damaged tendons, blood vessels, joints, and bones. X-ray examination for fractures and foreign bodies should be done when feasible. The wound should be irrigated through a 19-gauge needle with 150 mL or more of sterile normal saline or lactated Ringer's solution. Devitalized tissues should be débrided. Drainage of the wound, when indicated, can be performed in customary fashion or by using gentle suction with a 19-gauge scalp vein tubing connected to a vacuum blood-collecting tube. A controversy still exists regarding whether or not bite wounds that are clinically uninfected and are seen within 24 hours should be surgically closed. Margins of puncture wounds should be excised and left open after irrigation. Margins of other wounds should be excised and primary closure carried out, with or without drainage. The utility of suturing fresh bite wounds less than 6 hours after the injury is undetermined, except for facial wounds. Delayed primary closure or edge approximation should be done in wounds associated with crush injury, preexisting edema, and injuries to the hands or feet. In caring for a bite by a monkey that may be a B-virus carrier, the wound should be thoroughly scrubbed with soap or detergent and irrigated for at least 15 minutes, and viral cultures should be performed after cleansing. Serum for B-virus–

specific c acute viral serology should be stored at -20°C, and compared with a second sample obtained 21 days later. Antiviral therapy with acyclovir, valacyclovir, or famciclovir should be given to those with moderate or high-risk wounds. Bites of the hand are at the highest risk of deep damage and severe infection because sharp teeth may penetrate tendon sheaths or the mi palmar space. Human bites should be treated by widely opening the wound, debriding, and irrigating thoroughly; primary closure and tendon and nerve repair should be delayed. Following debridement and irrigation, dog bites can be considered clean, and primary closure can be performed. Hospitalization may be necessary in severe cases, with immobilization by splinting or bulky dressings and elevation. Facial bites, especially of children, require meticulous management. The majority of victims demonstrate positive outcomes with meticulous debridement, thorough irrigation, cleansing, and loose closure by suture. Close monitoring for a minimum of 5 days is essential. Subsequent plastic reconstruction might be necessary, and consulting with a plastic surgeon during the initial repair can be beneficial. Early and comprehensive management of all human bites, particularly those affecting the hand, is imperative. Clenched-fist injuries, in particular, demand more intensive care, preferably by a hand surgeon, to assess the extent of injury to the tendon, sheath, joint capsule, joint, and bone. Rabies prevention measures should be administered following dog bites that indicate such precautions.This includes hyperimmune serum and active immunization. A tetanus toxoid booster should be administered if the patient has been adequately immunized before and has received the most recent dose within the past 10 years. Tetanus immune globulin (human) is required if tetanus immunization has not taken place or is inadequate. The infectious complications of dog bites make the concept of prophylactic antibiotics attractive. Using antibiotics may be helpful, particularly in high-risk wounds such as those of the hand. The choice of a particular antibiotic for prophylaxis and/or treatment must be based on bacteriology. Unfortunately, no single antibiotic can be expected to effectively treat infections caused by all the organisms that can be present in an infected bite. The role of prophylactic antimicrobial therapy in bite wounds presenting early is uncertain. However, because these wounds are usually contaminated with potential pathogens, pre-emptively treating all patients having deep bite wounds with antibiotics is advisable. These include puncture wounds, facial bites, and any wound over a tendon or bone. Antimicrobial treatment should be administered for all bite wounds, with the exception of patients who present 72 hours or more after injury and have no clinical signs of infection. Antimicrobial therapy of bite wounds is not usually prophylactic, but rather a therapeutic intervention [51-54]

ANTIMICROBIAL THERAPY

Prophylactic treatment

The use of antibiotics in documented cases of bite wound infection is justifiable. However, consensus on the prophylactic use of antibiotics after a bite is less clear and remains a subject of controversy. Some authors argue that antibiotics should be considered therapeutic rather than prophylactic, asserting that no bite can be deemed 'clean' due to the accompanying bacterial inoculation. Others take a more conservative approach, suggesting that antibiotic prophylaxis may be unnecessary for minor wounds when the patient is not at high risk for infection. Furthermore, patients who present more than 24 hours after the injury without signs or symptoms of infection may not require antibiotics, as the majority of wound infections manifest within this time frame. If true prophylaxis is the goal, it has

been suggested that antibiotic serum concentrations should be therapeutic within 3 hours after the injury. It is likely that many injuries are not evaluated this quickly, and if oral antibiotics are administered, the inherent absorption time would increase this delay. Although parenteral antibiotic administration to achieve early therapeutic serum concentrations before emergency department discharge may appear useful, literature recommendations do not support this level of aggressiveness for uncomplicated wounds. Several randomized, prospective clinical studies have attempted to address the use of prophylactic therapy following bite wounds. Unfortunately, most of these studies have not been able to detect significant differences. Callaham provided the earliest data of prophylactic antibiotic usage in 98 patients presenting within 24 h of injury to reduce infection associated with dog bites. A 10% infection rate was demonstrated in patients receiving oral penicillin prophylaxis vs. a 25% rate in patients receiving placebo for a total of 5 days; however, statistical significance was not achieved. Although not a primary endpoint of the study, a trend between groups was noted in those suffering from hand wounds (16·6% infection rate with penicillin vs. 50% with placebo). Unfortunately, 42% of the eligible patients did not complete the study and no assessment of patient compliance was made [55-63].

Empiric therapy

An appropriate emperic antibiotic regimen must be directed at the pathogens most likely to cause infection, including both aerobic and anaerobic bacteria. Therapy should target organisms from both the oral cavity of the animal causing the bite, as well as potential pathogens from the skin flora of the victim. For dog and cat bites, therapy should include coverage of S. aureus, P. multocida, streptococcus spp. and anaerobes. Human bite therapy should likewise provide coverage of gram-positive and anaerobic organisms, as well as Eikenellacorrodens, with little concern over P. multocida. The clinician should be aware of the increased incidence of β-lactamase-producing organisms associated with human oral flora, which may be important in the evaluation of a failing antibiotic regimen.

Transmission of other infections

Cat scratches, cat bites, and flea bites have the potential to transmit the cat scratch-disease agent Bartonella (formerly Rochalimaea) henselae. Tetanus can result from both animal and human bites, necessitating an assessment of the patient's tetanus immunization status after skin-penetrating bite wounds. Tetanus toxoid and/or tetanus immune globulin should be administered when necessary or if uncertainty exists regarding the timing or prior receipt of tetanus immunization.

Bites, abrasions, scratches, or exposure to animal saliva through mucous membranes or breaks in the skin can all serve as avenues for rabies transmission. Considering the potential for rabies exposure is crucial after most animal bites, particularly in unprovoked attacks or if the animal appears ill or was a stray. Timely administration of postexposure prophylaxis can prevent unnecessary fatalities. Human bites carry the risk of transmitting other infections, including hepatitis viruses B (HBV) and C, primary syphilis, and herpes simplex virus. Due to the very low risk of transmitting HIV through saliva, postexposure prophylaxis is not recommended. [64-67].

Prevention Strategies and Public Health Implications:

Public health initiatives that center on responsible pet ownership, education about animal behavior, and the implementation of wound management protocols are pivotal in preventing infections arising from bites. Swift interventions following a

bite substantially decrease the risk of subsequent complications.

CONCLUSION:

The intricate interplay between microbial agents and host defences in animal bite wound infections embodies a multifaceted realm of microbiological complexities. This review has navigated through the diverse spectrum of pathogens, host-pathogen interactions, treatment challenges, and future directions, shedding light on the pivotal role of microbiology in shaping infection outcomes and therapeutic strategies. Host-microbe interactions delineate the dynamic equilibrium governing infection outcomes, wherein factors such as wound depth, inoculum size, and host immunity intricately dictate the infection's progression. The polymicrobial nature of these wounds, often harbouring diverse microbial communities, accentuates the complexity and challenges in treatment strategies. Antibiotic resistance emerges as a formidable hurdle, necessitating judicious antibiotic selection and the exploration of alternative therapeutic modalities. Diagnostic advancements, particularly molecular techniques, offer promise in precise pathogen identification, enabling targeted interventions and informed therapeutic decisions. Beyond therapeutic aspects, preventive measures and public health initiatives underscore the significance of responsible pet ownership, wound management protocols, and education on animal behaviour. These efforts serve as primary avenues for mitigating the risk of animal bite-associated infections. This conclusion encapsulates the multifaceted aspects explored in the review, emphasizing the crucial role of understanding the microbiological intricacies in animal bite wound infections for enhancing clinical management and developing effective preventive and therapeutic strategies.

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